WORLD ANIMAL REVIEW

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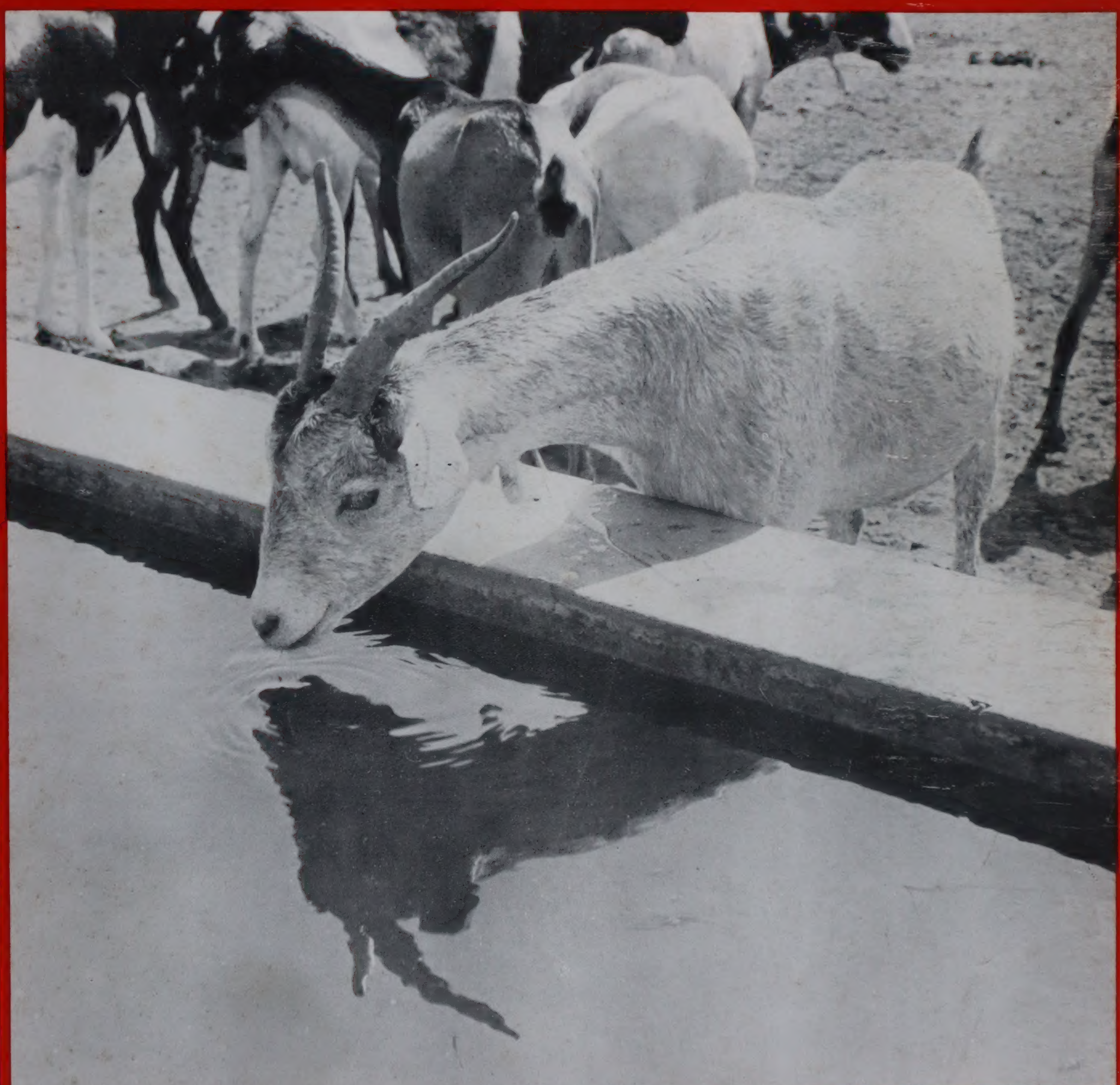

1975

A QUARTERLY JOURNAL DEVOTED TO WORLD DEVELOPMENTS IN ANIMAL PRODUCTION, ANIMAL HEALTH AND ANIMAL PRODUCTS

World Animal Review

No. 13, 1975

CONTENTS

Cover: Goat at a watering trough in the Labgal region of northern Senegal.

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World Animal Review, abbreviation: *Wld Anim. Rev. (FAO),* is prepared by FAO's Animal Production and Health Division which is one of five divisions in the Agriculture Department. The Division is subdivided into three technical services concerned with livestock research and education, meat and milk development and animal health.

World Animal Review

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MILK PRODUCTION FROM SHEEP AND GOATS

by C. Gall

Anand, India. A nomad shepherd with his flock of sheep and goats.

The contribution of sheep and goats to total world production of milk from all dairy animals is about 3.4 percent. It varies from 0.3 percent in North America to 17 percent in Africa (Table 1). The variation is even greater within regions. In the People's Democratic Republic of Yemen, sheep and goat milk contribute 90 percent of total production, while in 15 countries, mostly in the Near East and Mediterranean area, the contribution exceeds 50 percent.

Table 2 shows that in the 20 countries with the highest per caput production of sheep and goat milk, the contribution of this sector to total milk supplies ranges from 19 to 93 kg per caput per year. These figures may be compared to total milk production per caput of human population of 28 and 37 kg (from all species) in Asia and Africa and 260 and 660 kg (from cows only) in the United Kingdom and the Netherlands respectively. In some countries the contribution of sheep and goat milk production to total milk production is low, although in absolute terms production levels are high. In these countries, the importance of sheep and goat milk is in relation to a speciality market such as cheese production in France.

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Dairy sheep and goats in agricultural systems

Although there is a wide variety of agricultural systems under which sheep and goats are exploited for their milk, many of them are not

well defined and some operations change from year to year according to local conditions, market situations and so on.
Three principal systems may however be recognized:

- large flocks that practise some form of migration;
- large specialized sedentary flocks;
- small holdings, mainly for family supply.

Milk production from sheep and goats operates under a migratory system in many countries in the Mediterranean basin and in the Near East. During winter, the flocks are kept close to or in the lowland agricultural areas, grazing aftermath or fallow, and are often fed straw. With the advent of spring and the onset of agricultural activities and pasture growth on the range, the herds move toward the hills and mountains. Animals in late pregnancy and early lactation are retained in the lowlands until the lambs and kids are weaned. However, most of the milk for marketing is produced while the flock is on the range and away from the urban centres.
Migratory systems are characterized by difficulties of securing an even feed supply all year round, of handling and marketing milk and dairy products and all the socioeconomic problems arising from transhumance.
Large herds may be kept under a sedentary system where grazing that is unsuitable for cattle is available the whole year round. Examples of such a system are found in Latin America, where goats are herded and cover considerable distances daily between pastures and corrals. Matings take place over the whole year, but nearly always there is one season in which, due to lack of feed, kiddings are rare and milk production is very low, with individual goats sometimes producing less than 100 g milk. This results in seasonal variations in the price of milk, and of kids, which are a valuable by-product. Supplementary feeding at the end of pregnancy and during early lactation is seldom practised, although it has been shown to be economic.

Spain. A flock of Manchega sheep grazing crop residues, which can be an important part of the annual cycle of fodder supply.

TABLE 1. Milk production in countries having highest production from sheep and goats (1972) [1]

Country/area	Cows	Buffaloes	Sheep	Goats	Sheep and goats	
					Combined	Per cent of total
	Thousand tons					*Per cent*
Morocco	455	[3]	308	293	[2] 601	57
Sudan	1 400		140	450	590	30
Algeria	315		117	107	224	42
Niger	100		13	119	132	57
Africa	10 180	1 035	777	1 494	2 271	17
Mexico	3 300			190	190	5
North & Central America	68 472			218	218	0.3
South America	19 883		29	132	161	0.8
Turkey	2 350	270	870	566	1 525	35
Iran	980	48	540	221	761	42
China	3 369	1 008	426	270	696	14
Pakistan	2 840	7 680	293	398	691	6
India	8 100	15 000		650	650	3
Bangladesh	3 582	420	13	524	537	12
Iraq	250	35	288	60	348	55
Afghanistan	323	3	278	66	344	51
Yemen Arab Republic		70	53	139	192	73
Asia	28 682	25 004	3 134	3 218	6 352	11
France	29 177		870	300	1 170	4
Greece	540	6	450	350	800	59
Italy	9 810		430	110	540	6
Spain	4 400		190	250	440	9
Romania	3 650		385		385	10
Bulgaria	1 300	30	320	50	370	26
Europe	151 529	47	2 971	1 504	4 475	3
U.S.S.R.	82 600		100	500	600	0.7
World	374 622	26 086	7 012	7 066	14 078	3.4

[1] SOURCE: FAO Production Yearbook Vol. 26, 1972. Selected countries in which more than 190 000 tons of sheep plus goat milk are produced. — [2] Countries are arranged within regions according to quantity of sheep plus goat milk produced. — [3] Blank spaces indicate that production is negligible or no figures are available.

TABLE 2. Milk production from sheep and goats in relation to human population (1972)[1]

Country	Human population	Milk production			
		Sheep	Goats	Proportion of total[2]	Sheep and goat milk
	Thousands	... *Thousand*	*tons* ...	*Percent*	*Kg/yr per caput*
Cyprus	633	25	34	74	93
Mauritania	1 227	43	69	56	91
Greece	9 020	450	350	59	89
Mongolia	1 367	48	38	36	63
Albania	2 251	50	51	51	45
Bulgaria	8 597	320	50	26	43
Yemen, Dem.	1 357	8	47	90	40
Turkey	37 562	870	566	35	38
Syrian A.R.	6 613	190	52	53	37
Morocco	16 526	308	293	57	36
Sudan	16 819	140	450	30	35
Iraq	10 393	288	60	55	34
Niger	4 088	13	119	57	32
Yemen A.R.	6 074	53	139	73	32
Iran	30 158	540	221	42	25
Malta	327	2	6	24	24
France	51 721	870	300	4	23
Afghanistan	17 878	278	66	51	19
Mali	5 344	33	67	49	19
Romania	20 726	385		10	19

[1] SOURCE: FAO Production Yearbook Vol. 26, 1972. Countries are listed in order of per caput production. — [2] (Sheep + goat milk) ÷ (Cow's + buffalo + sheep + goat milk) × 100.

Keeping large herds of sheep and goats in most European countries implies some fodder conservation for the winter period; but with considerable additional inputs for fodder conservation and housing, the small ruminants enter into competition with cattle. To successfully compete with cattle, the development of specialized intensive milk production by sheep and goats depends on various factors:

- a market for the specific products paying prices considerably higher than for cow's milk;
- sufficient volume of production to support specialized processing and marketing;
- possibilities to overcome seasonal lowered milk production.

Specialized large-scale operations producing sheep milk have been developed in France, Israel, Italy (Sardinia), Spain, Bulgaria and Romania. Various types of cheese are the main products and some countries have developed an important export trade. Intensive and sometimes large-scale goat operations of 100 to 1 000 goats are found in France for cheese production, in Latin America for cheese and liquid milk and in the United States (California) for liquid milk production destined mainly for a specific health food market.

In the central European alpine regions, cattle are traditionally pastured during the summer months on distant grounds of higher elevation in the Alps, too far away to supply the villages with their daily milk. Since grasslands in the valleys are all utilized for haymaking to ensure winter feed supply, no grazing is available to dairy animals for home milk production during the summer months. This daily supply is therefore secured from goats that are able to utilize grazing inaccessible to cattle and that can cover considerable distances and differences in altitude daily and return to the village for milking. However, due to manpower limitations this kind of operation is fast disappearing.

Keeping small numbers of animals for family milk supplies is less common with sheep (with the exception, perhaps, of the old system of keeping East Friesian sheep) than with goats, where the practice is almost universal. But, in most countries little is known about the extent of this kind of goat keeping, which can be a very important source of animal protein in the human diet.

Lactation characteristics

It is not easy to define dairy breeds of sheep and goats except according to the functions for which they are maintained. Some breeds that are kept mainly for the production of meat or fibre are milked occasionally. Levels of production are not a suitable criterion since there are breeds considered as dairy breeds that do not exceed the milk yields of, say, the Mutton Merino with 150-200 kg per lactation. Neither is milking ability suitable to distinguish dairy breeds, since there are some sheep breeds that are milked regularly but lack an adequate let-down of milk. However, a few sheep breeds can be classified as dairy breeds on account of their high milk production and good milkability. These are the Awassi of the Near East, Chios of Greece and Turkey, Churro of Spain, East Friesian of Germany, Sardinian of Italy and Lacaune of France.

Some of the best known dairy goat breeds are those of alpine origin — the Alpine, Saanen, Toggenburg. Other goat breeds outstanding for their milk production are the Granada/Murcia of Spain, Jamnapari of India, Nubian of northeast Africa and Shami (Damascus) and Mamber of the Near East.

Both sheep and goats have seasonal lactations. They mate in autumn, produce progeny in spring, and the length of the lactation period is limited, so that as a rule animals are dry during late autumn and early

winter. There is some genetic variation in seasonality and in some breeds births occur throughout the year. Since periodicity of reproduction is governed by differences in day length, it is less marked in the lower latitudes. But as temperature and nutrition interact, quite irregular patterns may result.

Seasonality of reproduction and lactation is certainly an important factor in the adaptation of sheep and goats to seasonal feed supplies. But where commercial milk production is desired, with a view to supplying a market throughout the year, methods of obtaining year-round lambings/kiddings are of considerable interest. In the lower latitudes, an adequate feed supply and some shelter may be sufficient to achieve this, but in higher latitudes out-of-season breeding requires hormonal treatment. In areas with a continuous feed supply, some goats — preferably the better milkers — may not be mated during the first season following kidding, so as to extend their lactation periods and provide for out-of-season milk production. Alternatively, cheese or curd might be produced during the flush season for later use. Where hard-type cheese is produced, storage does not present a major problem, but where the market is for soft cheese that cannot be preserved for an extended period, curd can be frozen for later processing. In France there is legal provision for producing and marketing goat cheese from mixed milk containing only 50 percent goat milk (*mi-chèvre*). In areas with a less developed market, goat milk (seldom ewe's milk) is indiscriminately marketed together with cow's milk.

Duration of lactation is dependent on genetic factors, feed supply and the adequacy of milking techniques. Average lactation length varies between breeds from 100 to 210 days in Lacaune to 260 days in Awassi and East Friesian (Table 3). The recorded quantity of milk produced excludes that suckled by the young. Although, under favourable environmental conditions and with adequate feeding, the best dairy goats and sheep can produce an average of 2 litres per day, 1 litre per day must be regarded as excellent production. However, the conditions that allow for a daily production of 1 litre of milk for 250 days or more per year readily lend themselves to the keeping of dairy cattle. As a result, in environments that are typical for sheep and goat keeping, milk production is much lower and often animals are milked that produce 300 grams or less per day.

Milking

Milking may commence either after weaning or when the animals are still nursing their young. A common practice is to separate the dams from their young in the morning and during grazing and to milk them upon their return from pasture in the evening. It has been shown that combined suckling and milking results in a greater production of milk than milking without suckling. Apparently this is due to a greater stimulation of milk production by the suckling young, both directly (hormonal) and indirectly (better evacuation of the mammary gland). The transition from suckling to milking that takes place at the time of weaning causes a decrease of about 30 percent in the milk obtained from the ewe (Labussière *et al.*, 1973). This is mainly the result of reducing the frequency of milk withdrawal. After weaning and during peak lactation, animals are usually milked twice daily, but this is reduced to once a day toward the end of lactation. The management of the milking herd could be considerably simplified and production costs reduced if milking could be limited altogether to once a day either over the whole lactation period or toward the end of the period, and if a rest day for the milkers could be organized once a week. The loss of milk resulting from once-a-day milking differs with breeds, the age of the ewe and the stage of lactation. In the Sardinian breed, suppression of one milking resulted in a loss of 12 to 15 percent; but this could be reduced to 5 percent if, during the first one or two weeks after weaning, milking was twice a day (Casu *et al.*, 1973). In the "Préalpes du Sud" breed, the loss is greater, about 30 percent less milk being obtained from once-a-day milking (Labussière *et al.*, 1973). The omission of one afternoon milking a week (Sunday afternoon) resulted in a loss in total lactation yield of 12.8 percent in adult Sardinian ewes and 25.6 percent in yearling ewes of the "Préalpes du Sud" breed. Although losses in adult ewes of the latter breed may be less, it appears doubtful whether this practice can be recommended generally. It may therefore be concluded that limiting milking to once a day during the latter part of lactation might result in net savings, depending on the level of production, milk prices, costs of milk collection and processing, and labour costs.

The development of milking machines, milking parlours and suitable milking routines for milk production from sheep and goats has received considerable attention. The mechanical principles applied are largely copied from those used for cattle. Experience shows, however, that this

TABLE 3. Milk production from sheep and goat breeds

Breed	Lactation length	Milk production
	Days	*Kg*
SHEEP		
East Friesian	260	500
Awassi	260	130-270
Chios	170-260	100-250
Sardinian	170-250	110-230
Lacaune	100-210	135
Iran, fat-tailed breeds [1]	75	169
GOATS		
Saanen (France) [2]	300	700-900
Saanen (Israel)	280-335	650
Shami	276	600-700
Granada/Murcia	275	600-700
Jamnapari	210-283	211-272
Nubian (Egypt)	60	60-70

[1] Under improved conditions (Demirüren, 1972). — [2] Recorded goats.

Milking methods (from top to bottom): Lebanon — the Mediterranean Bedouin traditionally tie sheep head to head for milking. Indonesia — a simple rack facilitates the milking of the family goat. France — in intensive sheep management systems, mechanical milking has become a highly sophisticated process.

is far from satisfactory, especially for sheep. The different physiological mechanism of milk flow, the storage capacity of the cisterns and the size and shape of the teats call for many modifications. In view of the limited number of outfits that can be expected to be sold, it is not surprising that industry is slow in developing and implementing improvements. In machine-milked ewes, milk often flows in two peaks and it has been common practice to remove the teat cups after the first peak, thus allowing time for the alveolar milk to be ejected, and then putting on the teat cups a second time. This procedure results in high labour requirements. Milking routines have been developed recently where the second application of the cups is suppressed; if carefully followed and employed by well-trained staff, the quantity of milk loss can be quite low (Ricordeau, 1973). About 80 ewes milked by one man per hour is quite a common performance in France and Israel using various types of milking parlours. It is envisaged that this performance can be increased to about 200 ewes per man per hour through improvements in equipment and working routine (Sharav, 1973).

Handling and marketing of milk

Some indicative data on milk composition are given in Table 4. The composition of goat milk is very similar to cow's milk, but some breeds, particularly dwarfs, produce milk high in fat content. Ewe's milk, on the other hand, is more concentrated in both fat and protein. In specialized intensive operations the milk is handled largely in the same way as cow's milk. Prices are, as a rule, higher than for cow's milk, giving credit to the specific flavour and quality of the milk and its derivates or to the higher yield of cheese as in ewe's milk. They fluctuate by seasons and in more developed markets take composition into account. Under the more typical extensive production system, often including herd migration, marketing presents serious problems. The quan-

tities produced are limited and are further reduced by considerable home consumption in the form of sour milk, butter or ghee, and cheese from whole milk, skim milk or buttermilk. Sometimes the producers market these products themselves, but more often they rely on merchants who collect and process the milk. Such small-scale cottage-type operations are well established in many areas. They often install their mobile units at, or close to, the nomad camps and have firm relationships with the producers, sometimes contracting and paying in advance for the season's production.

It is in the very nature of the system that hygienic conditions of milk processing leave much to be desired and the quality of the products is subject to considerable variation. However, it is difficult for industrial dairy plants to compete with the small dealer who is flexible and is operating at low cost. When striving for improvements in collection, processing and marketing, it may thus be desirable to make use of an established system rather than to replace it, in order to ensure adequate remuneration for the producer and the manufacturer of dairy products, so that the products will continue to be within the reach of the underprivileged group of consumers. In some cases, it would be preferable to support the small merchant and help him to improve his relationship with the producers. One way of doing this is by extending credit directly to producers and to merchants and giving technical assistance for the improvement of production and processing systems.

An experimental mobile cheese-making unit to be stationed in camps of migratory herds has been tried out in Lebanon. While shepherds will deliver considerable quantities of milk which otherwise might be poorly utilized or even wasted, the economics of operating such a unit would require a considerable throughput. Careful planning to ensure a sufficient quantity of milk would be necessary. Furthermore, the unit must be fully mobile and should be able to reach camps of difficult access (Westergaard, 1972). In France there is a traditional cottage-type production of goat cheese by small stock owners which is declining but surviving (Le Jaouen, 1974).

TABLE 4. Average milk composition of various ruminants

	Goats	Sheep	Cattle
	Percent		
Dry matter	11.5-13.5	16-20	13
Fat	3.5- 8.0	5- 8	3.4-5.4
Protein	2.8- 3.0	5- 6.5	3.5-4.0
Lactose	3.9- 4.4	4.4	4.6

By-product meat

Most of the breeds used for milk production are quite prolific, twins being the rule in adult animals. In fact, meat is an important by-product of dairy sheep and goats and contributes up to half of the total income. When prices and demand for meat of young milk-fed animals are high, they are allowed to suckle more, and consequently less milk is available for commercial purposes. But under environmental conditions typical for sheep and goat production, lactation is often insufficient to nurse the young. In order to secure a cash income, thrifty animals may be sold for slaughter, leaving the stunted for replacement purposes — a practice that can seriously affect the phenotypic and genetic quality of the herd. Some of the observed "degeneration" often attributed to inbreeding is in reality due to this kind of unconscious selection.

A different practice common in goatkeeping is to sell one kid of each set of twins at a very early age, say, one week, in order to secure adequate development of the other twin. Thereby a considerable potential for meat production is lost. By the introduction of artificial rearing, premature slaughtering could be avoided and animals eventually carried to higher slaughter weights. The feasibility of this practice depends on the availability of milk replacers, on growth rate and feed conversion, and on consumer acceptance of heavier carcasses. While limited experiments seem to indicate that improvements are possible in this field, more research is needed.

Disease

Dairy animals are basically affected by the same diseases as other sheep and goats, but some diseases have specific importance — mastitis, infectious agalactia, brucellosis and *Ecthyma contagiosum*. Mastitis is essentially the same complex as in cattle. There is, however, a high frequency of histolytic streptococci causing gangrene of the udder. In goats multiple nodular abscesses can be a problem.

Infectious agalactia can reach quite a high incidence, but vaccination has been reported to protect animals for at least 11 months (Damdinsuren, 1966). Brucellosis is of particular importance because it is transmissible to man, the main carrier being milk. Since the microorganism is not inactivated by the preparation of cheese except during prolonged ripening, pasteurization of all milk is imperative in areas where the disease occurs. Brucellosis is best controlled through the culling of reacting animals, a measure which can be economically feasible because the value of the individual animal is low and fertility is high. Control through vaccination with REV 1 vaccine is also possible and may be combined with testing and culling, since the complement fixation reaction generally returns to negative within six months (Alton, 1973).

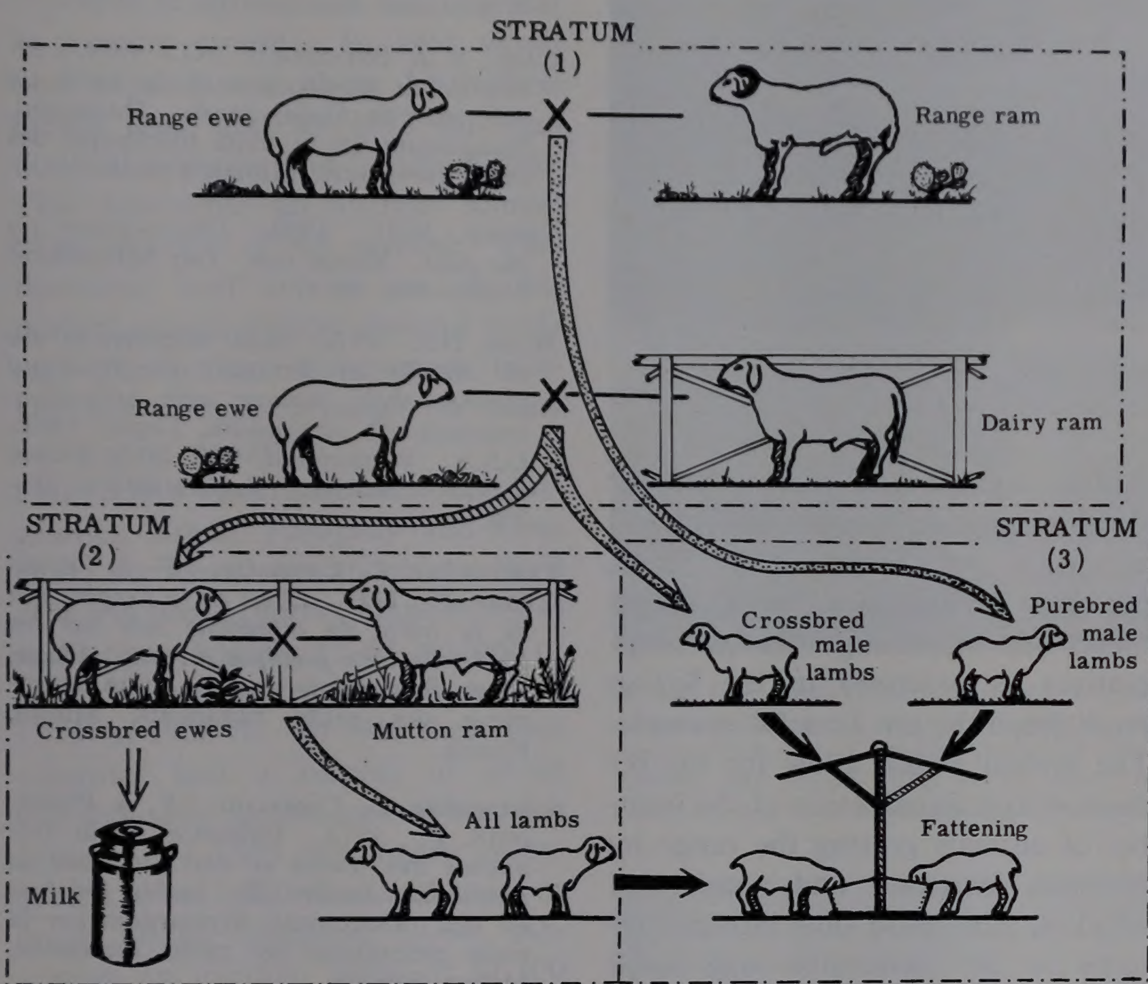
Contagious ecthyma is a common but rather harmless ailment in young sheep and goats. If, however, udders are affected, it can cause considerable distress in milking animals. Vaccination is possible but control is not easy, possibly due to a multiplicity of immunogenically different virus strains. The virus is transmissible to man and can occasionally cause quite distressing skin lesions. While the goat is not completely resistant to trypanosomiasis, it is much less susceptible than cattle. The goat can therefore be a very

valuable tool for protein production in tsetse areas.

A strategy for the future

There is doubtless a tendency in many areas of traditional milk production from sheep and goats to reduce stock numbers or to limit milking. There are many reasons for this trend but some of them seem to be quite universal: labour involved in milking small animals, social status of small-stock men, limited market for products, preference for cattle products and conflicting interest in utilization of grazing grounds. It appears, however, that a thorough analysis would often reveal the advantages of small-ruminant milk production for improvement of the agricultural structure and the small farmer's situation. Where labour is a limiting factor, this has to be overcome by the application of modern techniques. Social status is closely linked with labour conditions and income. The most important limitation appears to be market acceptance and prices. While small-ruminant milk production might have clear advantages, it cannot be introduced in some areas because the market would not accept the produce. But, where there are natural conditions better suited to sheep and goats than to cattle, and where there is relatively ample manpower available and a market with superior prices for the products, there is a strong case for milk production from sheep and goats. It is then a matter of improvement of production and management to make it a viable sector that is integrated ecologically and socioeconomically. By formulating appropriate policies, giving technical assistance and credit facilities, governments should encourage this production where appropriate.

One of the major concerns over sheep and goat keeping is their impact on vegetation. French (1970) and Huss (1972) have discussed this problem. It is evident that goats do not necessarily destroy vegetation; it is their mismanagement that creates danger. Eliminating sheep and goats as a measure of range protection would mean eliminating the human population that earns a living from these animals.



Stratification of sheep production in zones of low and high potential

Organizing a production system that would integrate the range with the areas of higher agricultural potential through stratification could increase economics in both areas (Demirüren, 1972). Morag (1972) has proposed the adaptation for Near East conditions of stratified production systems as practised in the United Kingdom, Australia and New Zealand. This is presented below with some modifications.

Three different strata are envisaged (see diagram):

1. The range.
2. Areas suitable for intensive milk production.
3. Areas suitable for fattening.

The base population on the range would be a hardy breed like the Awassi that is well adapted to adverse conditions. Some of the ewes would be mated with dairy breeds like the East Friesian, to produce crosses for stratum (2). If and when range management can be improved, crossbred ewes could also be used on the range and higher grades produced for stratum (2). Crossbred ewes would be used exclusively for milk production in stratum (2); they would be mated to mutton rams (like the German Mutton Merino) and the crossbreds transferred to stratum (3). These crossbreds would benefit from the increased size of their dams and the mutton characteristics of their sires and would exhibit some hybrid vigour.

Stratum (2) need not be geographically distant from (1); it can be adjacent to the range, thus allowing for continuous movement between (1) and (2). In stratum (2) in its most refined form, the proportion of lactating ewes would be kept high by making them lamb every eight months or by sending them back to the range for the dry period. Lambs would be weaned early, but with an accelerated breeding programme they would need to be reared artificially if milk replacers are available.

Lebanon. Mobile cheese-making unit

The whole system of stratification depends on organization. Thus, operators in strata (1) and (2) must know that their returns will be higher if they produce crossbreds for the next stratum, rather than if they sold surplus animals in the traditional way. They would need to rely on sales at the appropriate time. On the other hand, raising foundation ewes in stratum (1) and transferring them to (2) must be more economical than raising ewes for replacement in strata (2) and (3). Ideally, the whole system should be controlled by one central organization responsible for range management improvement and allocation of (emergency) feeds, breeding programmes, stock movements and marketing. Range cooperatives as practised in the Syrian Arab Republic are a useful example. The system would allow for the reduction and stabilization of the number of animals grazing the range by planned, increased and accelerated offtakes, and could thus increase returns to the pastoralist and make both milk production and fattening more rewarding.

THE NEXT ISSUE OF WORLD ANIMAL REVIEW

will include articles on the following subjects

Early weaning in buffaloes in Egypt

Imitation milk and imitation milk products

International collection and dissemination of information on animal feeds

Major impediments to export of meat and animals from developing countries

Hides, skins and animal by-products — directions for development

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The benefits for economic development from selected South American beef exports

by J.R. Simpson and D.E. Farris

Slaughtering and packing beef for export is a big business and one that is growing rapidly. In 1961 world beef exports were about 1.5 million metric tons, and by 1972 this had doubled to more than 3 million tons. This represents an average annual trend increase of 5.4 percent. Furthermore, beef exports are an important source of gross national product, employment, government revenue and foreign exchange for many developing countries.

Four South American countries, Argentina, Brazil, Paraguay and Uruguay, accounted for about one third of world beef exports (Simpson, 1974) and approximately 55-60 percent of world canned beef exports (Simpson, 1973) in 1966-70. In 1965 these four countries had a surplus of about 670 thousand metric tons of beef for export. By 1985 this figure is expected to be 1 300 thousand tons, or nearly double (Simpson, 1974). Assuming an average value of $1 500 per ton, this would be $1 950 million in foreign exchange earnings by 1985. There has been very little research published on the economic gains from various forms of beef exports despite the beef industry's importance and the high priority given to the industry by both national and foreign planners for over 25 years. Consequently, a study was conducted to provide some criteria for measuring the economic benefits and to examine some policy considerations which could apply to the Latin American beef-exporting countries.

It would be expected that more processing prior to export would yield more value added (in an accounting sense), thus providing greater economic development per unit of cattle production, especially in countries with chronic unemployment. The method for estimating the amount of economic development from further processing is by economic multipliers. While multipliers have been developed for the meat industry as a whole in nearly all input-output studies,[1] multipliers for specific lines of products are not available for either developed or developing countries.

Five different beef exports have been selected for study: live cows, bone-in beef quarters, frozen boneless manufacturing beef, cooked/frozen beef and canned beef. The analysis is limited to cow beef in all models.[2]

Because a general statement applicable to all the Latin American beef-exporting countries was desired, budgets prepared from interviews were inserted in the 1963 and 1970 Argentina input-output studies, the 1959 Brazilian study and the 1961 Uruguayan study (Banco Central de República Argentina, 1964; Ellis,

A full line packer, this company in Brazil can produce all types of domestic and export products. Changing domestic price ceilings and export tariff policy result in changing the mix and volume of output.

This fully integrated beef-canning plant in San Antonio, Paraguay, operates up to six months each year. It produces mostly canned beef products for export but could ship higher value frozen boneless cuts from the better quality cattle.

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[1] Input-output studies for a number of Latin American countries were constructed by the United Nations Economic Commission for Latin America (ECLA) in the late 1950s and early 1960s (Chenery and Clark, 1959). A more complete discussion of input-output models in Latin America is currently being prepared by ECLA in Santiago, Chile. A preliminary report was presented in August 1973. Other relevant reports are Ghosh (1968, 1971), Hirsch (1959) and Maki (1970). The planning application is generally on import substitution or the very macro level. So far as is known, studies on application to decision making for a specific industry in a developing country have not been published.

[2] Beef from steers, although comprising the majority of all beef exports, is almost always broken down into numerous wholesale cuts which depend on market conditions and customers' orders at the time of slaughter, while a cow carcass is frequently directed entirely, or almost entirely, to one of the four product forms listed. Thus, restricting the analysis to cow beef simplified the study.

1969; Argentina, 1973; Uruguay, 1969) to derive economic multipliers for these countries. Traditionally, the Central American countries have shipped chilled or frozen beef with little processing, while Argentina, Brazil, Paraguay and Uruguay have exported the entire gamut, from live animals to sides of beef to canned corned beef. Due to their diversity, only the South American countries were selected for study.

English-type breeds provided these frozen "pistola" cuts for export to Europe from Uruguay. The less valuable cuts from these steers were used for frozen boneless trimmings and canned beef.

Fully integrated beef-packing plants

A flow diagram of beef processing in a fully integrated South American beef-packing plant is presented in Figure 1. As is evident, some operations, such as killing and subsequent cooling, are common to all beef products. On leaving the cooler, carcasses for all products except bone-in beef quarters require deboning and trimming. Only meat surrounding large bones is exported in the form of boneless manufacturing beef (used by importers in further processed products such as frankfurters, hamburger, and canned products containing beef). Small pieces of meat which can only be trimmed with a relatively high amount of labour are transferred to the cooking operation for processing into other types of product or sold to other packers. After manufacturing meat is deboned, it is wrapped in plastic and placed in cartons which weigh about 20-25 kg, and then frozen.

These thin steers and bulls awaiting slaughter in Columbia were consumed locally; they could have been exported as canned beef or frozen boneless beef for manufacturing, and the company would have collected a subsidy.

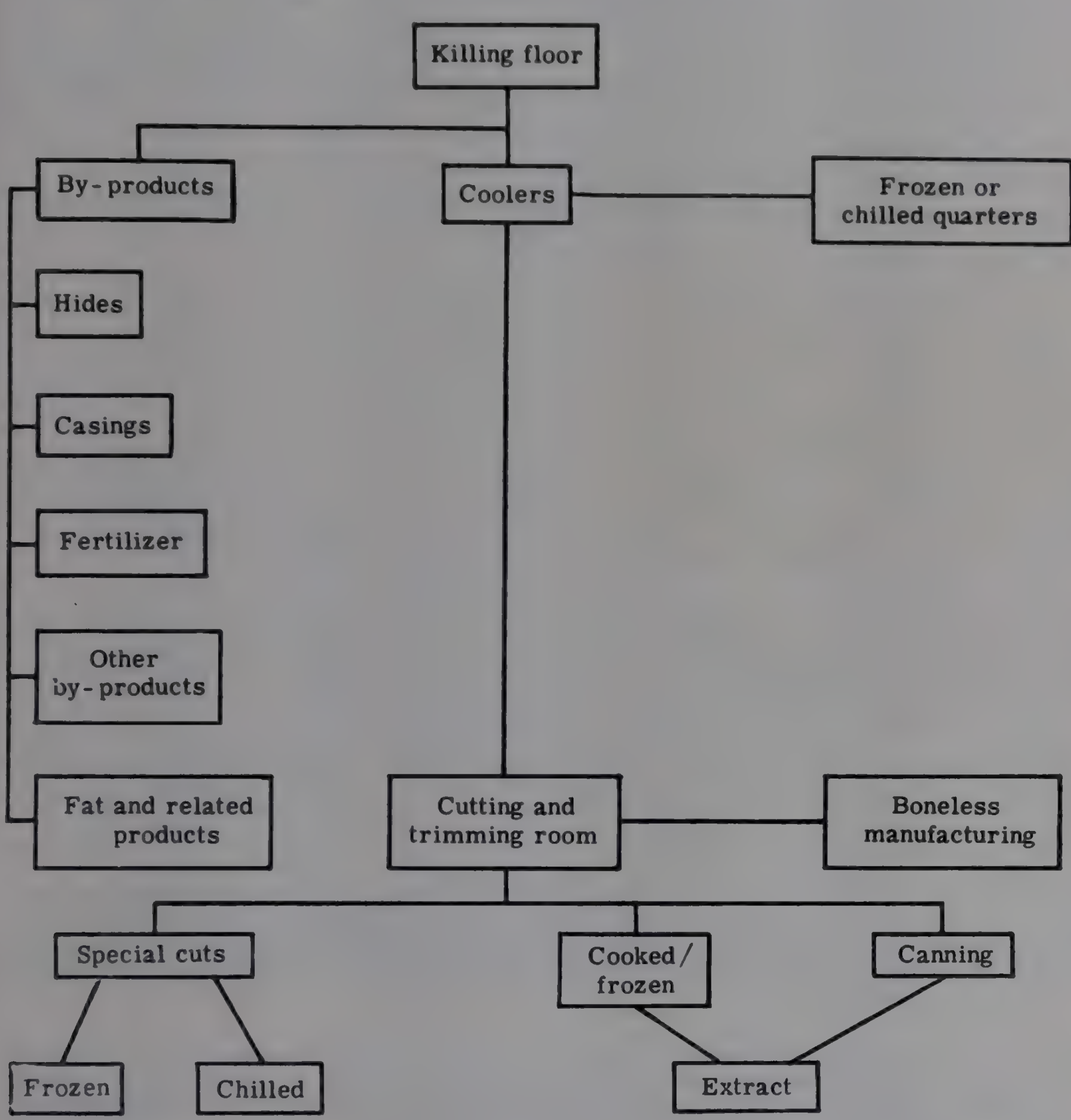
The meat for cooked/frozen beef is also first deboned from the carcasses, although less care is taken in the process than for manufacturing beef since it is cut in small pieces. Other bones such as ribs are also trimmed.

The meat is then dumped into a horizontal cooker through which it slowly passes and the cooked meat, as well as the broth called extract, is expelled at the opposite end. The extract is passed through a filtering process to remove excess fat and particles. Then it is packed and exported for further processing into items such as bouillon cubes. The meat is pressed into plastic tubes and frozen. Cooked/frozen beef is mainly used by importers for further processing in products such as *chili-con-carne* or other products requiring cooked meat.

The product was developed in 1951 by Deltec International Ltd., a United States corporation which at that time had extensive holdings in South America. Cow beef is used, but the greatest proportion of cooked/frozen beef (and canned beef) originates from steers. The purpose in developing the product was to provide an alternative to canned beef for the United States market which would also comply with United States sanitation standards resulting from South America's endemic foot-and-mouth disease. There are no published sources of world trade in cooked/frozen beef, but an indication of the volume can be obtained by examining Argentina's exports as, except for Brazil, Argentina has been the only exporter of any consequence. Argentine exports increased from about 3 000 tons in 1964 to 29 000 in 1970. At an average value of $1 500 per ton in 1970, the value of that year's exports was $43.5 million. The United States receives the bulk of these exports with most of the remainder going to the European Economic Community.

As shown in Figure 1, the process for canned beef is the same as for cooked/frozen meat except that after leaving the cooker it is mixed with condiments (see canning memoranda of the Continental Can Co. Inc.). About 20 percent more fat is usually added for corned beef, while for other canned products such as beef gravy or beef cubes little or no fat is added. The mixture is then poured into a large hopper and automatically portioned out to the cans. The small cans are automatically vacuum sealed while the large 6-lb (2.7-kg) cans are frequently closed by hand. All cans are placed in a retort and the contents cooked again, after which they are stored and then checked for defects.

1. *Flow diagram of beef processing in model packing plant.*



Effects of changes in final demand on GNP and income

The selection of an economic sector for development stimulation can be based to some extent on direct and indirect impacts on output (gross national product) and income. To demonstrate how the results of the disaggregation process can be applied, the effects of a $1 million change in final demand on the five subsectors analysed, using multipliers from the 1963 Argentine input-output study as a base, are considered.

Cost models for a typical 1 400-head-per-day capacity plant were constructed from data obtained during July and August 1973.[3] From these budgets it was determined that the processor's greatest costs are for the raw product, varying from 62 percent of the total for canned beef, where the product is quite concentrated, to 81 percent for bone-in quarters. These percentages are inversely related to labour use, which varies from 4 to 15 percent of the total costs (Table 1). The budgets were inserted in the various input-output studies and run on a computer from which the multipliers were derived. The output multipliers (type II) for the 1963 Argentine study, as well

[3] From extensive interviews with two large international packers in Paraguay, three in Argentina, three in Uruguay and one in Brazil.

as the other Latin American studies, are given in Table 2. The interpretation is that for each $1.00 worth of exports there are $X worth of direct, indirect and induced effects generated in the economy. In all cases the product ordering was the same and very little difference is observed in the absolute size of the multipliers. As a means of investigating the general applicability of the analysis, a sensitivity test was made by inserting the budgets in an input-output study for the state of Texas in the United States (Grubb, 1973), hypothesizing that this would represent an extreme situation. Texas exports large amounts of bone-in beef to other states, but is part of a developed interdependent economy. The multipliers resulted 25 percent lower than the Argentine studies, probably because of the leakage due to imports of cattle and materials from other states. Cooked and canned beef differed less from the manufacturing beef reference point while quarters varied more; however, the ordering of the multipliers was essentially the same, suggesting that the method of product economic evaluation through the use of input-output studies is relatively flexible with respect to the input-output study chosen.[4]

The effect that a $1 million change in export sales would have on the base economy is presented in Table 3.[5] The total change is much lower for live cow exports than any of the other products. Cooked/frozen beef is highest, with $4.87 million output and $1.16 million income. Canned beef is second, with $4.41 million output and $940 000 income. Quarters and manufacturing beef are about the same and tie for third place. Assuming that economic development is the goal, the estimates shown in Table 3 indicate that cooked/frozen or canned beef should

TABLE 1. Estimated pretax costs for bone-in beef quarters, frozen boneless manufacturing beef, cooked/frozen beef, canned beef, and live cow exports, liveweight basis, 1973

Item	Direct and indirect costs				
	Bone-in quarters	Frozen boneless manufacturing	Cooked/ frozen	Canned	Live cow exports
	Dollars per metric ton				
Livestock	302.11	302.11	302.11	302.11	302.11
Fuel and electricity	7.89	8.41	6.25	4.92	
Foods				1.26	
Meats				5.89	
Textiles	4.17				
Ready-made wearing apparel	0.49	1.84	2.13	4.38	
Wood	0.40	0.35	0.28	0.63	
Paper and cartons		6.86	3.43	6.79	
Printing and publications				0.63	
Chemical products				0.04	
Metals				2.00	
Vehicles and machinery	1.53	1.75	2.09	3.13	
Other industries		1.40	6.56	0.95	
Commerce	6.58	9.31	11.99	11.99	
Transportation and storage	5.56	6.09	5.13	2.86	23.87
Other services	8.97	9.60	9.68	10.95	2.90
Labour	17.83	48.35	56.08	73.72	13.09
Depreciation	11.58	9.53	11.98	20.00	
Defective cans				0.00	
Imports	5.82	6.12	8.91	32.75	
TOTAL	372.93	411.72	426.33	485.00	341.97

SOURCE: Simpson (1974).

TABLE 2. Output multipliers for export of live cows, bone-in beef quarters, frozen boneless manufacturing beef, cooked/frozen beef and canned beef from five different disaggregated input-output studies[1]

Input-output study	Type of beef export product				
	Live cows	Bone-in quarters	Frozen boneless manufacturing	Cooked/ frozen	Canned
1963 Argentina	3.33	4.04	4.01	4.87	4.41
1970 Argentina		4.05	4.03	4.85	4.41
1959 Brazil	3.19	3.77	3.68	4.76	4.18
1961 Uruguay	3.03	3.47	3.44	4.18	3.79
1967 Texas		3.07	3.15	3.37	3.25

SOURCE: Simpson (1974).
[1] Type II multipliers include direct, indirect and induced effects.

[4] The multipliers have been developed for exports of cow beef, but the results could be adapted with little modification to exports of steers. In all likelihood there would be no important difference in the absolute size, i.e., live steer exports can be expected to have the lowest multipliers followed by quarters. The various subprimal cuts from steers probably have a multiplier slightly larger than that presented for frozen boneless manufacturing beef, but smaller than that for canned or cooked/frozen beef. Only the lower quality steers and the less valuable portions of the higher quality steers would be considered the same class of raw product as cow beef.

[5] See Simpson (1974, Chapter 5) for a further explanation of multiplier derivation and interpretation.

TABLE 3. Effects of a $1 million change in final demand on income and output (GNP) for five types of South American beef exports

Exports	Change in output	Direct change in household income	Direct, indirect and induced income change	Direct, indirect and induced output (GNP) change [1]
	. . . . *Dollars*			
Live cows	1 000 000	27 860	568 001	3 331 400
Bone-in quarters	1 000 000	131 580	822 875	4 040 800
Frozen boneless manufacturing	1 000 000	58 170	762 068	4 007 400
Cooked/frozen	1 000 000	321 130	1 163 390	4 872 200
Canned	1 000 000	173 600	943 013	4 411 200

SOURCE: Simpson (1974).

[1] The change in output multiplied by the type II output multiplier for the disaggregated 1963 Argentina input-output study (Table 2).

receive the greatest emphasis, followed by either manufacturing beef or quarters.

Application of the analysis to planning in Uruguay

Projections developed elsewhere indicate the potential for exploitation of any export mentioned above (Simpson, 1973, 1974). Although it is impossible to determine the future share of each product of each of the exporting countries, a hypothetical situation can be created to evaluate several alternatives which a country might face. A nation which lends

TABLE 4. Estimated Uruguayan beef exports and three hypothetical output situations, 1975, 1980 and 1985

Model	Year	Beef available for export				Estimated final demand [2]				Projected direct and indirect effects [3]			
		Bone-in quarters	Frozen boneless mfg.	Canned	Total [1]	Bone-in quarters	Frozen boneless mfg.	Canned	Total	Bone-in quarters	Frozen boneless mfg.	Canned	Total
		. . . *Thousand metric tons* . . .				. . . . *Thousand dollars*							
I. Quarters 75%, manufacturing 25%, canned 0% [4]	1975	146.7	48.9		195.6	212 422	81 458		293 880	737 274	280 549		1 017 823
	1980	156.1	52.0		208.1	226 033	86 622		312 655	784 515	298 335		1 082 850
	1985	165.2	55.1		220.3	239 210	91 786		330 996	830 250	316 120		1 146 370
II. Quarters 45%, manufacturing 50%, canned 5%	1975	88.0	97.8	9.8	195.6	127 424	162 915	22 414	312 753	442 263	561 096	84 949	1 088 308
	1980	93.6	104.0	10.5	208.1	135 533	173 243	24 015	332 791	470 408	596 666	91 017	1 158 091
	1985	99.1	110.1	11.0	220.3	143 497	183 405	25 158	352 060	498 049	631 665	95 349	1 225 063
III. Quarters 25%, manufacturing 35%, canned 40% [4]	1975	48.9	68.5	78.2	195.6	70 807	114 107	130 266	315 318	245 757	392 996	493 708	1 132 461
	1980	52.0	72.9	83.2	208.1	75 296	121 437	138 595	335 328	261 337	418 241	525 275	1 204 853
	1985	55.1	77.1	88.1	220.3	79 785	128 433	146 757	354 975	276 918	442 336	556 209	1 275 463

[1] From Simpson (1974). — [2] The conversion coefficients for carcass weight to product weight are: quarters 1.00, manufacturing 0.7162, canned 0.6543. Final demand values are calculated by multiplying projected exports times the international price as of August 1973 for the major item extract and high priced cuts. The prices are: quarters $1 448.00, manufacturing $1 665.80, and canned $2 287.10. — [3] The type II multipliers are: quarters 3.4708, manufacturing 3.4441, and canned 3.7900. See Table 2. — [4] Percentages on carcass weight basis.

TABLE 5. Relationship between pretax costs and international prices for two periods, for five types of cow beef exports on a live animal basis [1]

Beef export product	Bone-in quarters			Frozen boneless mfg.			Cooked/frozen			Canned		
	Pretax costs [2]	International price		Pretax costs [2]	International price		Pretax costs [2]	International price		Pretax costs [2]	International price	
		Dec. 1970	Aug. 1973		Dec. 1970	Aug. 1973		Dec. 1970	Aug. 1973		Dec. 1970	Aug. 1973
Live cows	1.09			1.20			1.25			1.42		
Bone-in quarters	1.00	1.00	1.00	1.10	1.09	1.10	1.14	2.61	2.02	1.30	1.61	1.41
Frozen boneless manufacturing				1.00	1.00	1.00	1.04	2.39	1.83	1.18	1.47	1.28
Cooked/frozen							1.00	1.00	1.00	1.14	0.62	0.70

[1] Ratio calculated by dividing cost or price indicated by column headings by cost or price indicated by row headings. — [2] Both direct and indirect.

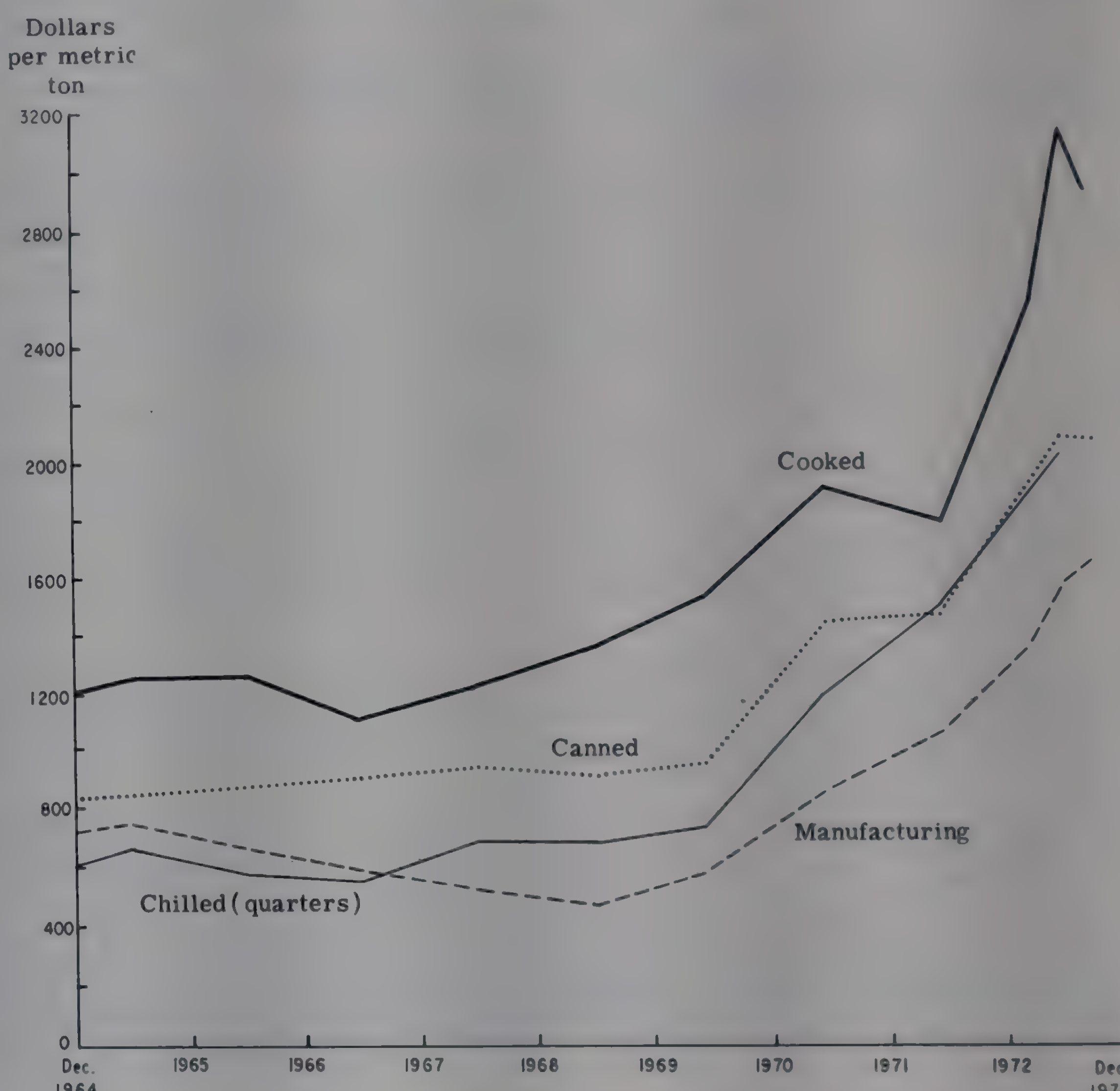
itself well to this type of analysis is Uruguay, where exports of canned beef have declined rapidly over the past decade, apparently due to political and economic instability and a general reluctance by government to encourage investment in this industry.

Three export policy models for Uruguayan beef are presented in Table 4. The first model assumes the product mix prevailing in the early 1970s, when bone-in quarters made up 75 percent of exports, frozen boneless manufacturing and special cuts 25 percent[6] and canned beef zero percent. Using projections of beef exports (Simpson, 1974) and August 1973 prices, $1 080 million of economic activity would be generated by 1980 if the same product mix and prices prevailed.

The Government of Uruguay has set targets in which quarters represent 45 percent of exports, manufacturing 50 percent and canned beef 5 percent. With this product mix $1 150 million of economic activity would be generated in the economy by 1980, given the earlier assumptions on price and quantity. This is an improvement of $70 million over the current export makeup.

An alternative in which canned beef plays an important role (40 percent of exports) is presented in model III. The direct and indirect benefits from this change are apparent, as $1 200 million of economic activity would be generated by 1980. This is $50 million (5 percent) more than the Government's target plan and $120 million (11 percent) more than the contemporary product mix. If the projections included cooked/frozen beef as one export product, the total direct and indirect activity would be even greater.[7]

New machinery must be imported to allow a canned beef or cooked/frozen beef industry to develop. The foreign exchange earnings are given in the columns headed "Estimated final demand." Under the government plan, about $333 million would be earned in foreign exchange by 1980. If the alternative with canned beef is adopted, $335 million in foreign



2. *Average international value of four beef export products, Buenos Aires, 1964-73.*

exchange earnings would cover the exchange lost due to the imported capital improvements in a few years.[8]

Value added and foreign exchange

Apart from the desirable impact on economic development from encouraging increased exports of products with the highest multipliers, a major government concern in Uruguay is the generation of foreign exchange. Thus, the Government would be expected to promote exports of the product with the greatest "value added" which also provides a profit to the packer. The value added criterion should be on a per animal rather than a per product basis, however, because different numbers of animals are required for each product. A ton of manufacturing beef, for example, requires 8.17 cows while only 5.89 cows are needed for a ton of quarters. Dividing the former by the latter gives 1.39, which means (assuming packers pay an equal price for cows) the export price

[6] The multiplier for a myriad of wholesale cuts from steers can be considered similar or slightly higher than the multiplier for manufacturing beef. All these products are therefore grouped together under the term manufacturing beef.

[7] The absolute size of the numbers will change due to price differences, supply availabilities, export taxes and structural changes which would affect multiplier size. Nevertheless, the *relative difference* can be expected to remain about the same.

[8] Beef production and consumption in Uruguay are extremely variable. Thus, the absolute size of the imports must be interpreted with care, as little confidence can be placed in the beef export projections. Furthermore, while some of the examples are for 1975, this is for expository purposes only, as it is recognized that the industry cannot shift to producing canned beef or cooked/frozen beef by that time.

of manufacturing beef would have to be 39 percent higher than quarters for the value of each product, on a per cow basis, to be the same. Processing costs must, of course, be considered.

The total pretax costs on a liveweight basis from Table 1 have been divided into each other and the subsequent coefficients presented in Table 5, together with a comparison of international prices for two different periods, December 1970 and August 1973. The coefficient of 1.10 at the intersection of bone-in quarters and manufacturing beef under "Pretax costs" means that manufacturing beef has about 10 percent higher costs than quarters on a live animal basis. Under the heading "International price" the 1.09 for December 1970 can be interpreted as meaning that the international price of manufacturing beef in Buenos Aires was 9 percent above quarters on that date. Two and a half years later it was 10 percent above quarters. Comparing the ratio of pretax costs with the price ratios shows that all three are almost exactly the same, indicating that the market was operating close to a cost of production for these two products.[9]

The rapid increases in international prices experienced after 1969 (Figure 2) do not affect the multipliers to any appreciable degree. In addition, it has been determined that considerable international price changes *between* products would be required for the relationships to change.[10] As can be observed in the figure, all products increased.

Overall, this analysis suggests that in either period a country shipping all products derived substantially more benefit, in terms of foreign exchange per animal slaughtered, from sales of cooked/frozen or canned beef than from quarters. Exporting manufacturing beef is the least attractive alternative, since the price/pretax ratios are lower than for quarters and the output multipliers are about the same.[11] The conclusion is thus that additional economic activity as well as foreign exchange earnings results from plans encompassing exports of further processed beef.[12] Finally, although the analysis was restricted to Latin America, *a priori* it would appear that the product ordering would be the same in terms of output and income benefits for almost every country in the world.

Where there is chronic unemployment and a constant need for increasing business activity and foreign exchange, national policy makers could well afford to consider those policies that would encourage the production and export of cooked/frozen beef and canned beef. Obviously, this requires careful analysis of potential markets and the feasibility of investments, but the payoff from the multiplier effects are substantial when a successful operation is established.

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[9] The assumption that the pretax cost relationships which were prepared in August 1973 also hold for December 1970 is implicit. While the relationships are for cow beef, they hold even when beef from steers is included in the analysis.

[10] A price series for live cow exports was not available; thus the relationship between this alternative and other products cannot be discussed.

[11] Clearly, it must be cautioned that all beef-exporting countries in Latin America cannot expect to develop an export market based on canned beef or cooked/frozen beef, as the limits to growth are bounded by market demand. Nevertheless, fiscal policies and trade restrictions can be placed on the export of manufacturing beef, which is used to a great extent by the importing countries to produce goods which compete with cooked/frozen beef and canned beef. This would have the effect of increasing the size of the market for cooked/frozen and canned beef.

[12] The multiplier from cooked/frozen beef and canned beef is sufficiently high that governments of Latin American nations other than the four examined in detail in this study may find it advisable to promote the development of the canned and cooked/frozen beef industries, with one modification — diversification into canned product lines other than corned beef. Some examples are beef stew with vegetables, canned Mexican food, corned beef hash, and Italian spaghetti sauce. Other, newer processes are producing canned or frozen beef containing varying proportions of meat extenders.

THE TROPICAL ADAPTATION OF BEEF CATTLE

an Australian study

by **H.G. TURNER**

The Australian tropics cover 36 percent of the country's area, and the raising of beef cattle is the main form of land utilization in this region of 2.8 million square kilometres.

Figure 1, showing mean temperature corrected to sea level, demonstrates that northern Australia is comparable in this respect to other tropical regions. But temperature is less moderated by elevation in Australia than it is in many other regions.

Figure 2 shows the distribution of beef cattle in Australia and some isohyets of rainfall. More than half of tropical Australia has a rainfall of less than 500 mm and only limited coastal areas receive more than 1 000 mm. The rainfall is strongly seasonal (monsoonal) and of low reliability. Conditions range from small but significant areas of wet tropics to major areas of aridity. There is little scope for arable cropping or fodder conservation and the industry is essentially pastoral and extensive. Because of low carrying capacities, it is difficult to moderate the natural range environment to which the cattle are exposed.

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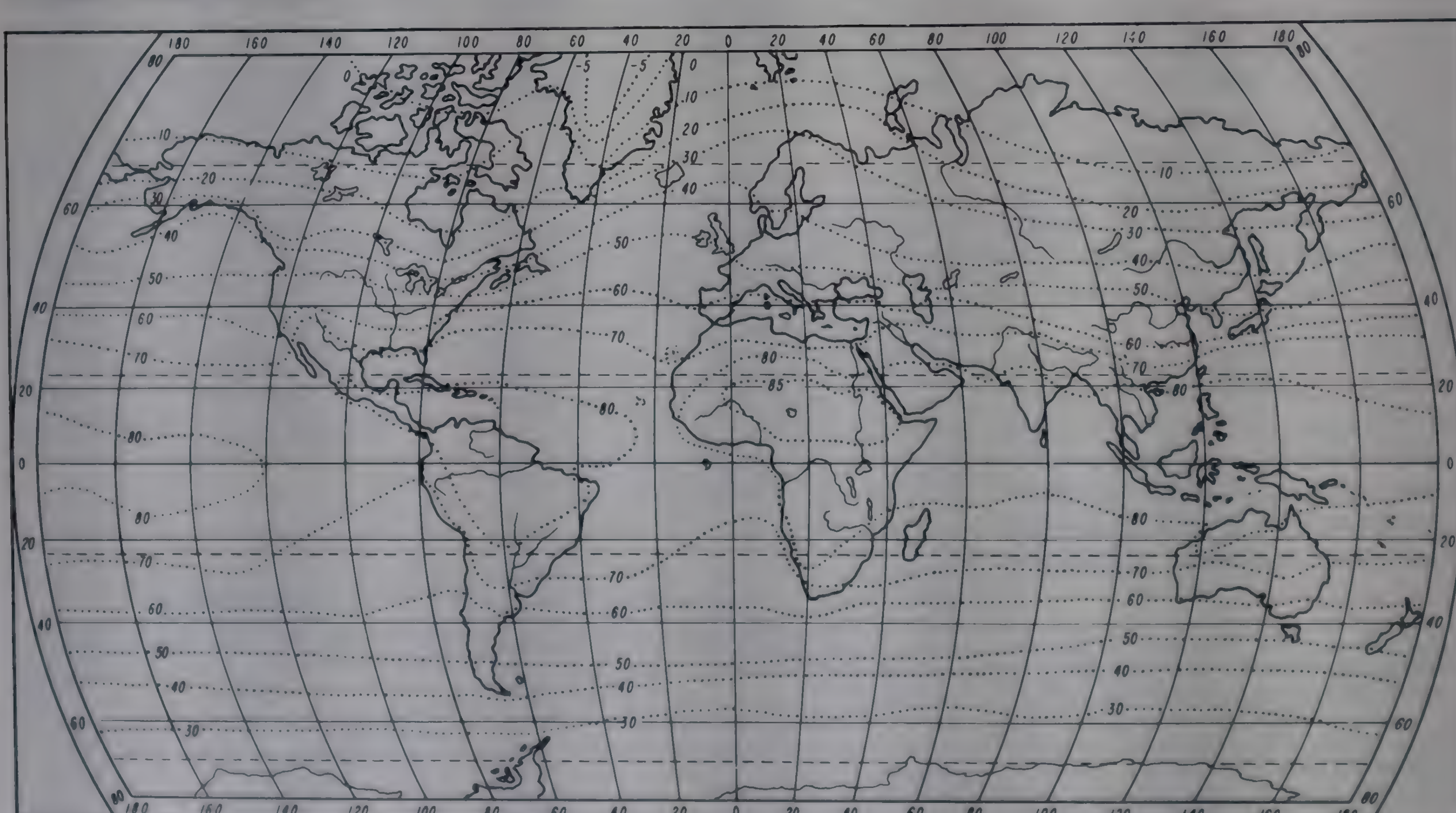
1. *Mean annual world temperatures at sea level (Fahrenheit).*



SOURCE: Thomas A. Blair and Robert C. Fite, *Weather elements: A text in elementary meteorology*, 5th ed., 1965. By permission of Prentice-Hall, Inc., Englewood Cliffs, New Jersey, U.S.A.

2. *Beef cattle distribution and rainfall in Australia.*

Australia is free of the major infectious diseases such as foot-and-mouth disease, rinderpest, surra and pleuropneumonia, which are excluded by strict quarantine. The cattle tick (*Boophilus microplus*) and its associated blood parasites, *Babesia* and *Anaplasma*, are endemic throughout the less arid parts of the region; gastrointestinal parasites and biting insects, including the buffalo fly (*Siphona exigua*), affect the well-being of cattle.

Unlike most countries within the tropics Australia had no indigenous cattle and, by historical accident, the area was colonized by British breeds. In northern Australia the Shorthorn has been predominant, supplemented by the Hereford in limited areas, as the industry was established in the middle of the nineteenth century.

Introduction of tropical cattle

Whereas most tropical countries have indigenous *Bos indicus* cattle and look to the introduction of *Bos taurus* to improve productivity, in northern Australia it has been necessary to introduce tropically evolved cattle. The approaches to the target of adapted, productive cattle from opposite starting points are instructive. In each case the focus of interest tends to be on the novel qualities to be introduced, sometimes to the neglect of those already established which are taken for granted.

Quarantine regulations have limited the sources and extent of importations of tropical cattle. The early entry of a few zebu cattle and of buffalo and banteng had little impact, the former being dissipated and the latter isolated as feral populations. In 1933, 19 Brahmans were imported from the United States and distributed among a number of herds. These were followed in the 1950s by further imports of Brahmans and Santa Gertrudis, by a small number of Africanders (also from representatives of the breed in the United States) and by Sindhis and Sahiwals from Pakistan. The latter were intended primarily for dairy breeding, but the use of Sahiwals in beef breeding has been explored.

Belmont programme

The breeding programme at Belmont, the field station of CSIRO's Tropical Cattle Research Centre at Rockhampton, started in 1954 with representatives of Brahman, Africander, Hereford and Shorthorn breeds. This centre was set up for the study of inherited factors controlling adaptation and economic performance under northern Australian conditions. After initial matings with all combinations of breeds, the following are the main lines established and carried forward, currently, to the F_4-F_5 generation:

Africander cross: half Africander, quarter Hereford, quarter Shorthorn;
Brahman cross: half Brahman, quarter Hereford, quarter Shorthorn;
Hereford-Shorthorn: half Hereford, half Shorthorn.

These are referred to respectively as AX, BX and HS. In these and other subsidiary lines, a breeding herd of about 900 cows is maintained. They and their progeny are grazed on natural and improved pastures representative of the area and exposed to the normal stresses of the environment. Performance is compared principally under these conditions, but some growing stock are studied more intensively in confinement.

3. *Young bull of Africander-cross line. This highly fertile and adapted line, under selection for growth, fertility and parasite resistance, has become established under the breed name "Belmont Red."*

The location of Rockhampton is shown in Figure 2, and its meteorological data are given in Table 1.

Performance attributes

FERTILITY

The calving percentages shown in Table 2 represent breed means accumulated over a number of years,

corrected for the effects of age, lactational status and year (Seebeck, 1973a). These results were all obtained from a short annual mating period of seven weeks, with young (2-year-old) bulls and with single-sire matings (one bull to 30-35 cows). All three factors lower the level of fertility realized and emphasize differences in reproductive efficiency.

In matings of $F_1 \times F_1$, the differences between breeding lines were not significant, although both AX and BX were more fertile than HS. In subsequent generations, AX maintained high fertility, HS dropped slightly, and BX fell dramatically; the breed differences are highly significant. Reciprocal matings between the AX and BX lines, made simultaneously with straight matings of each line, have shown that the difference is expressed in both males and females.

Within the BX and HS lines, cows that are progeny of different sires differ significantly in fertility, with a heritability of 22-25 percent (Seebeck, 1973a). There is scope for improving fertility by selection, which would be enhanced by identifying the underlying genetic factors. Toward this end, the significance of morphological abnormalities of the female reproductive tract, semen abnormalities, serving performance, fertilization rates and postpartum anoestrus is being defined, and the endocrine bases of some of these differences are being elucidated.

Growth

The mean body weights of calves of the three breed lines are shown in Table 3. These represent 500-600 female calves of the F_2 and F_3 generations born over a period of five years. The breeds did not vary significantly in birth weight, but thereafter the differences were highly significant. At 18 months, BX were 21 percent heavier and AX 16 percent heavier than HS. These differentials are somewhat lower than in F_1 progeny, the decline from F_1 to F_2 being greater in BX than in AX, and more in birth weight than in subsequent weights.

In breeding cows, mature weights are very similar in the different breeds, but they are approached at different rates and differ in seasonal stability. During a drought, weight changes of nonlactating pregnant cows from February to October were: AX —8.7 kg, BX +5.8 kg, HS —33.0 kg. However, the changes of lactating pregnant cows were all similar at about —33 kg, the BX thus being most affected by lactation (Frisch, 1973a).

Table 1. Mean temperatures and humidity at Rockhampton, Queensland

	Mean daily maximum	Mean daily minimum	Relative humidity
	... °*Centigrade* ...		*Percent*
Jan.	32.2	22.4	68
Feb.	31.5	22.3	69
March	30.7	21.0	69
April	29.0	18.2	67
May	26.3	14.6	67
June	23.4	12.2	68
July	23.2	10.7	65
Aug.	24.8	11.6	64
Sept.	27.6	14.6	64
Oct.	29.9	17.7	63
Nov.	31.4	20.0	64
Dec.	32.2	21.6	66
Yearly average	28.6	17.2	66

Mortality

Table 4 shows mean mortalities of breed groups in calves of F_2 + generations from birth to 15 months and in adult cows (Frisch, 1973b). At all stages, mortality was least in AX and greatest in HS. Comparisons were similar in F_1 animals except that perinatal deaths were high in zebu-cross calves, especially those born to young British-breed cows. The mortalities of adult cows, averaged over a number of years, rose in two drought years to 5.6 percent in HS, 2.0 percent in AX and 1.5 percent in BX.

Carcass composition

The yield of carcass (dressing percentage) is higher, by about 2 percentage units, in BX than in AX or HS steers (Hewetson, 1962). The zebu-cross carcasses are leaner under some conditions but breed differences in fat content depend on stage of growth and plane of nutrition. Fat distribution shows some breed differences (Seebeck, 1973b). Distribution of muscle weight also varies, with AX better developed in muscles surrounding the spinal column and BX better developed in muscles of the upper hindquarter. In general, differences in yield and quality of meat at a given liveweight, although significant in indicating the potential for genetic improvement, are of minor immediate importance in most market situations.

Pure zebu performance

The foregoing compares the performance of *B. indicus* × *B. taurus* halfbreds with a line representing their *B. taurus* parents. Directly comparable data on the performance

Table 2. Calving percentages in Africander cross, Brahman cross and Hereford-Shorthorn lines

		AX	BX	HS
$F_1 \times F_1$	Number of matings	521	449	291
	Calving percentage	76.4	81.2	70.1
$F_2 \times F_3$	Number of matings	868	798	515
	Calving percentage	76.8	60.7	67.1

Source: Seebeck, 1973a.

Table 3. Body weights of Africander cross, Brahman cross and Hereford-Shorthorn heifers

	AX	BX	HS
	.... *Kilograms*		
Birth	29.6	28.4	30.8
Weaning	183.0	193.0	169.0
13 months	204.0	212.0	181.0
18 months	283.0	295.0	244.0

Source: Kennedy and Chirchir, 1971.

of the zebu parental breeds are less extensive, and it must be remembered that representatives of these breeds have only a small genetic foundation in Australia. Nevertheless it can be stated that compared with the crossbreds the Brahmans and Africanders have lower growth rate, lower fertility and higher juvenile mortality, but lower postweaning and adult mortality.

Genetic adaptations to components of the environment

The preceding comparisons of performance were recorded in a specific field environment. Obviously they would not be identical in all environments. Adequate definition of the physical and biological environment as it affects cattle is difficult to express in absolute terms, and it is more meaningful to identify and quantify elements of the environment in terms of their comparative effects on animal performance. This gives a perspective of elements limiting performance, the importance of genetic differences in response to them, and the genetic strengths and weaknesses of particular breeds.

Table 4. Mortality rates in Africander cross, Brahman cross and Hereford-Shorthorn calves and cows

	AX	BX	HS
	..... *Percent*		
Perinatal (0-7 days)	3.5	5.2	5.5
Preweaning	1.5	2.4	3.0
Postweaning (to 15 months)	1.1	1.2	2.7
Adult (annual) . . .	0.4	0.6	2.4

Source: Frisch, 1973b

Heat

The effect of the complex thermal environment occupied by an animal in the field cannot be predicted from experiments in climatic rooms. The effect of heat in a field situation has been estimated by clipping the animals' coats (Turner, 1962). Keeping Herefords clipped increased their growth during the six warmer months of the year by 13 percent. As clipping only partially relieved heat stress and lowered rectal temperatures to less than those maintained by zebu crosses under the same conditions, this is a minimum estimate of the importance of heat to a susceptible breed. Elementary parameters of the thermal environment in which these results were obtained are given in Table 1.

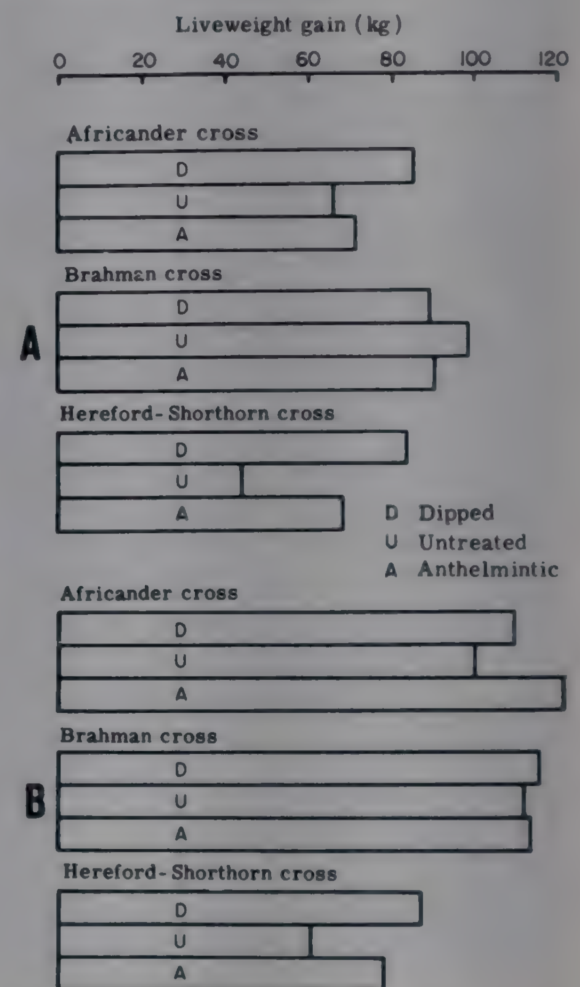
The superior heat tolerance of zebu crosses represents a significant advantage under warm conditions. Its main determinants are a sleek coat, high sweating capacity and low body heat production. Coat type is a good index of tropical adaptation in temperate breeds; it is related to sweating capacity (Schleger and Bean, 1971) and has a high heritability and genetic correlation with growth rate (Turner and Schleger, 1960).

Parasites and diseases

Breed differences in susceptibility to parasites have been studied by comparing responses to parasite control. In herds containing representatives of three breed groups, all run together at pasture and exposed to normal field infestations of the cattle tick (*B. microplus*) and gastrointestinal nematodes, one third of the animals were dipped twice or three times weekly to control ticks, one third were treated with anthelmintic every two or three weeks to control worms, and one third were left untreated. Gains of each treatment group of each breed in two different experiments (Figure 4) show that HS were profoundly affected by both ticks and worms whereas BX were unaffected by either and AX were somewhat affected by both. Genetic tick resistance, gained by breed selection, crossbreeding, and within-breed selection, is an important contributor to performance in endemic areas and the most efficient means of countering the tick. Genetic differences in susceptibility to gastrointestinal nematodes are obviously of similar importance. A criterion of helminth tolerance, as applicable for selection as are counts of mature ticks in selection for tick resistance, remains to be developed.

Infectious keratoconjunctivitis (pinkeye) is an affection common every-

4. *Liveweight gains of Africander cross, Brahman cross and Hereford-Shorthorn cross when dipped to control ticks, treated with anthelmintic to control worms, or untreated.*



Sources: Experiment A: Seifert, 1971; experiment B: Turner and Short, 1972.

where, and is usually considered to be of minor nuisance value. It has been shown (Frisch, unpublished) that affected animals have markedly reduced growth rates and that there are major breed differences in susceptibility.

These are a few examples of the existence of genetic differences in susceptibility to diseases and parasites. Genetic solutions must be considered as economical and ecological alternatives to other control measures.

Feed utilization

Genetic differences in the growth response of animals subjected to stresses such as heat or parasites are expressed through some aspect of feed utilization. Susceptible animals suffer depression of feed intake or effects on digestion or metabolism (e.g., Seebeck *et al.*, 1971). There are other inherent differences in feed utilization independent of environmental stresses. Voluntary feed intake per unit of liveweight is comparatively low in Brahmans, but they also have a lower maintenance requirement at a given liveweight (Frisch and Vercoe, 1969). It remains to be seen whether a low maintenance requirement, which is a component of efficiency and a great advantage under conditions of feed shortage, can be combined with a high feed capacity which promotes gross efficiency under conditions of abundant feed. For the present, a low maintenance requirement is of overriding importance where there is risk of seasonal feed shortage.

There is a tendency for zebu crosses to have slightly higher digestive efficiency than British breeds (Moran and Vercoe, 1972). Another genetic difference of potential importance for maintenance on low nitrogen diets is in the recycling of urea to the rumen. Zebu crosses maintain higher blood urea under certain conditions, and animals with low water intake and urine volume, advantageous in an arid environment, also conserve urea (Vercoe, 1967).

Genetic differences in the commitment of nutrients to fat or protein deposition, and in the relative depletion of fat or protein stores during weight loss, affect the efficiency of meat production.

Environment or genotype

In relation to the target of improving animal productivity there tend to be two schools of thought. One favours modifying environments to accommodate animals of the highest productive potential, the other favours neglecting any scope for ameliorating the environment and accepting the productivity of genotypes which withstand its rigours. Either is a prejudgement and neither alone gives optimum solutions. Freeing the environment of all limitations, in climate, disease, parasites and nutrition, is in some cases not feasible and in many not economical. Any managerial measure relying on inputs (buildings, mechanization, fertilizers, pest control) must be evaluated in terms of cost and benefit. Cost must be viewed not only in immediate monetary terms but with a long view of true costs of inputs such as fossil fuels and nonrenewable resources, and side effects on ecological balance. Cost-benefit evaluation of managerial inputs may be seriously misleading if limited to one genotype, ignoring genetic differences in response. Conversely, genetic solutions may be inefficient where scope for effective adaptation is limited and an environmental element can be transformed by minor inputs.

To optimize productivity it is necessary to study both factors: modification of components of the environment and genetic differences in response to them. The examples of such investigations at Rockhampton given in this article have been more comprehensively reviewed by Vercoe (1974).

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the commercial application of EMBRYO TRANSFER IN DOMESTIC ANIMALS

by
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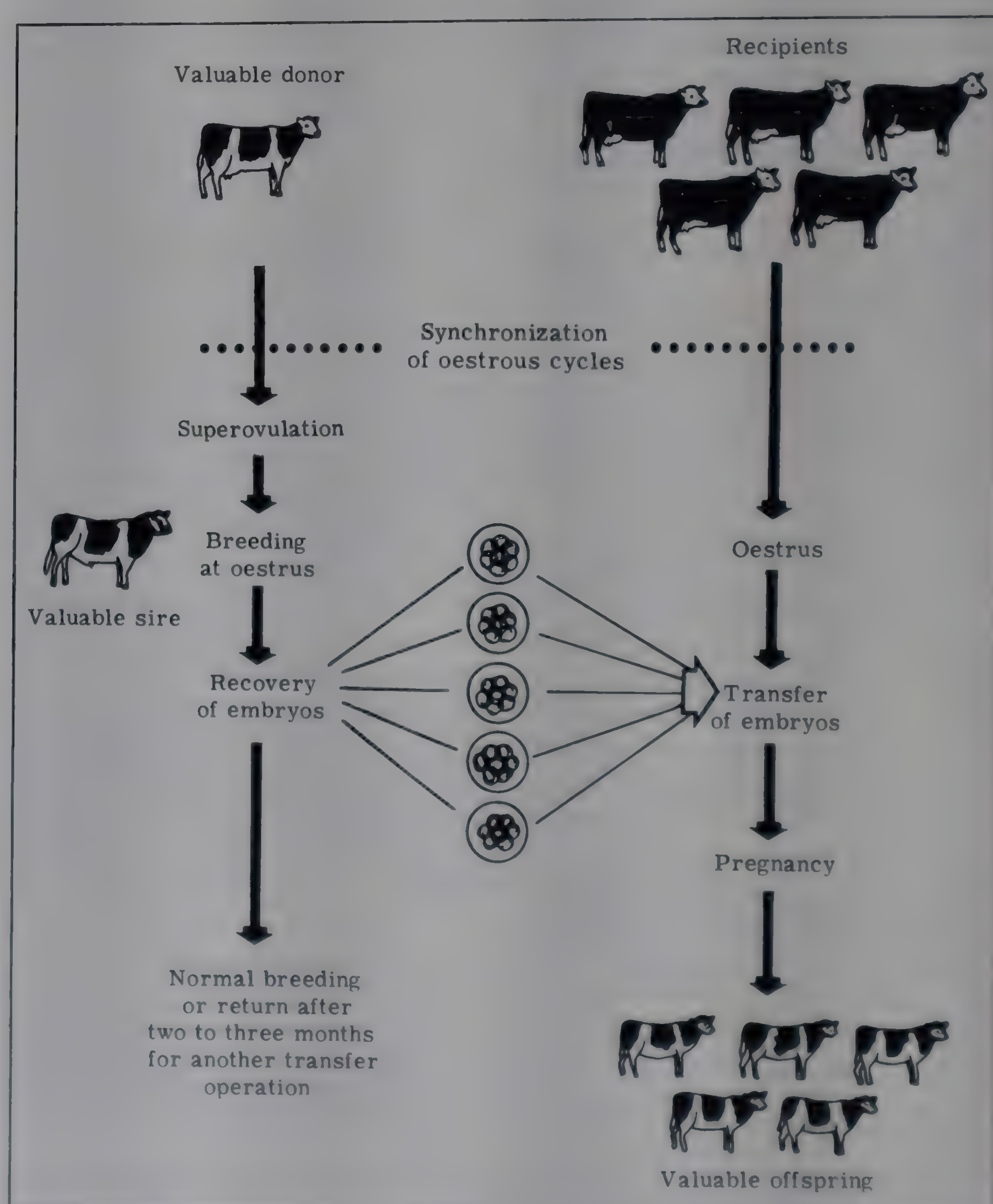
Embryo transfer is an artificial method of breeding whereby newly formed embryos prior to implantation are removed from a female animal and transferred into the reproductive tract of another female of the same species where they develop to term. The animal from which the embryos are removed is usually referred to as the donor, while the one that receives and carries the embryo is the recipient. The resulting offspring derive their genes from the donors from which they were removed and from the males to which the donors were bred.

Since the first successful embryo transfer in rabbits reported by Heape in 1890 in Cambridge, England, scientists in many parts of the world have used this technique quite successfully in other laboratory animals. In domestic animals transfers were reported by Warwick and Berry (1949) with sheep and goats, by Kvasnickii (1951) with pigs, and by Willett *et al.* (1951) with cattle. During the 1950s and 1960s further successful transfers were reported in domestic animals. These encouraging reports, together with that of Rowson *et al.* (1969) from Cambridge, England, led to the commercialization of this practice in cattle. Because cows (like some other species of farm animals) can be made to superovulate by hormonal treatment, this technique can be used to produce an increased number of calves per cow in a given period. It should thus be possible to multiply the progeny of a desirable female individual in somewhat the same way as artificial insemination does for the male. Although the technique is applicable to a number of domestic



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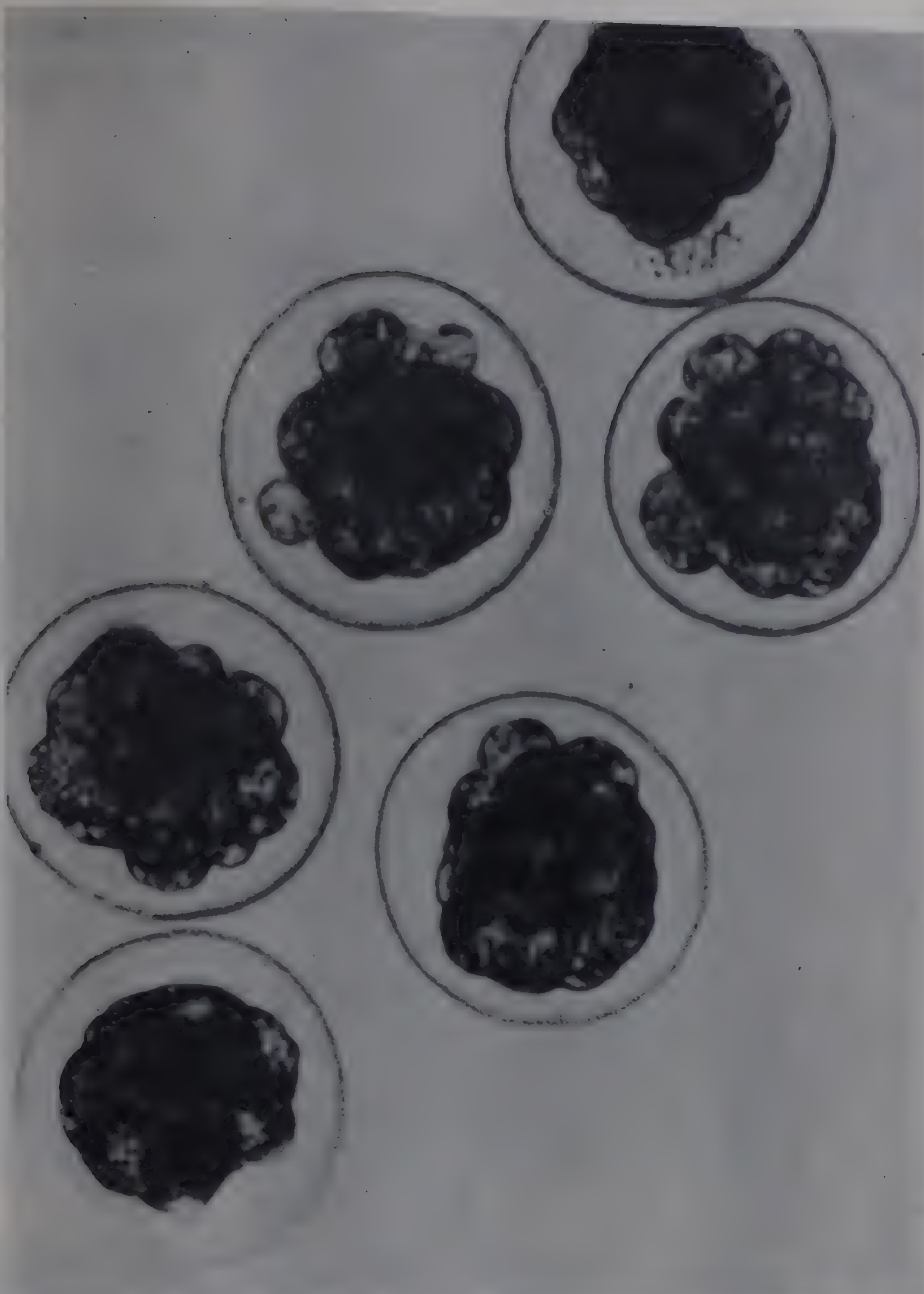

Group of embryos at about the 32-cell stage shortly after recovery (enlargement approximately × 100).

animals, the present article deals primarily with cattle since it is with this species that embryo transfer is now practised on a commercial scale. The major steps involved in an embryo transfer operation in cattle are as follows:

The donor cow is stimulated with a hormone (generally pregnant mare's serum gonadotrophin (PMSG) or follicle-stimulating hormone). Following such stimulation the animal comes on heat and she is bred or artificially inseminated with semen of the breeder's choice. In order to obtain maximum fertility two breedings are generally employed with a 12-hour interval, and a higher dose of semen is used the second time. It is expected that the donor will release a number of ova (10 to 15 or more) at this oestrus instead of the usual one. The ova are naturally fertilized within the donor and proceed to develop. If these embryos are left to grow in the donor cow, resorption and/or multiple pregnancies may result which are undesirable in cattle because of resulting complications and the possible occurrence of freemartins. About four to five days after breeding (when the embryos are freely "floating" within the uterus and are not yet implanted), the embryos are flushed out with a suitable biological medium.

This recovery procedure is best accomplished surgically, whereby the uterus of the donor animal is brought into view through an incision either through the midline or the flank. The operation takes about one and a half hours. Both the uterine horns are flushed by passing a tube through the uterine wall from one end and a hypodermic needle from the other; the medium is gently forced by a syringe and collected in a suitable dish. The embryos at this stage are still microscopic (approximately 0.2 mm in diameter) and are usually in the 32-cell stage of development. The dishes are then examined under a dissecting microscope. The embryos are picked up with a small amount of medium by a small glass pipette attached to a microsyringe and are then transferred surgically into the recipient animal's uterus by puncturing the uterine wall with a blunt needle and inserting the pipette carrying the embryo through it, followed by gentle pressure to eject the embryo into the uterine lumen. Embryos are transferred within four to five hours of recovery; during this time they are stored with minimum changes of temperature and pH.

It is important that the oestrous cycle of the recipient animal be synchronous with that of the donor (both donor and recipients should be in heat on the same day). In order to achieve this, it is necessary either to maintain a herd of approximately 250-300 regularly cycling animals to ensure about 12-15 recipients coming on heat every day to match with a given donor, or artificially synchronize the oestrous cycle of a smaller group of recipients to occur on a predetermined day when the donor is expected to come on heat. This

can be achieved with a satisfactory rate of success by using various oestrus-synchronizing agents; prostaglandins have been found to be quite suitable and do not appear to impair fertility.

The basic steps involved in embryo transfer are diagrammatically represented in the graph on page 22.

Commercial feasibility

During the past few years a number of organizations have been set up in several countries, including Canada, the United States, the United Kingdom and Australia, to offer embryo transfer service to cattle breeders on a commercial basis. The skilled and specialized techniques necessary for a successful operation have set a relatively high cost for this service. Under current North American market conditions the value of offspring from cattle imported from continental Europe, such as Limousin, Simmen-

1

2

According to
an average o

1. Embryos are located and examined under the microscope prior to transfer. 2. Embryo recovery performed by a surgical team on a donor cow. 3. A recipient cow being prepared to receive an embryo. 4. Eight Charolais calves (5 females and 3 males) produced by the donor cow on the far right; some of the recipients that carried these calves can be glimpsed in the background

ent performance, it is possible to produce calves per donor cow in 15 months

tal, Charolais, Blond d'Aquitain and Maine-Anjou, is high enough to justify the cost, which is about $2 000 for each operation plus $2 000 for every diagnosed pregnancy resulting from it. The value of a calf should thus be at least $4 000 to warrant the operation, although, of course, the greater the number of pregnancies obtained the lower the cost will be per calf.

At present the success rate obtained commercially averages between two and three pregnancies per operation. More than 65 calves were born and over 150 pregnancies have been established by the writers' services during the first year of their programme. There is great individual variability in response to treatments as well as in the number of established pregnancies. It has already been possible to produce more than a dozen pregnancies from one single collection of fertilized ova. The process of collection can be repeated quite successfully on the same cow. In the writers' programme at present two operations are usually performed on a donor within a two- to three-month period for the collection of fertilized ova, and they recommend that a natural pregnancy follow this. Based on their present success rates, it is therefore possible to produce an average

of five calves per donor cow within a 15-month period.

The genetic implications of this for cattle breeding could be substantial. The time element involved in establishing a new herd or upgrading a cattle population under specified circumstances can be considerably reduced. The development of inbred female lines is possible for crossing purposes. Furthermore, one could use only the top 10 percent of the herd to provide replacement stock. It is important that only genetically superior females be propagated by this technique.

According to the current success rates the economic feasibility of embryo transfer in cattle is justified in certain circumstances. A number of technical problems do exist, however, and their solution may greatly advance knowledge and improve the efficiency of this technology, leading to its more widespread use. The following are the major problem areas in which further research is indicated.

Great individual variability exists among animals in characteristics related to successful ova transfers. In the writers' experience, approximately two thirds of the treated animals produce pregnancies. A number of factors influence the results, including response to superovulatory treatments, recovery rate of superovulated ova, the quality of resulting embryos and the methods employed in handling and transferring them. Oestrus synchronization in the recipient herd is very important in increasing the pregnancy rate of transferred embryos. These problems are currently under investigation by many researchers, and improvements are expected.

Postsurgical adhesions that may result in the donor animal should be considered, as they may impair her future reproductive ability. Fortunately, they can be minimized with practice. With the method of uterine flush employed in the writers' clinic only the uterine horns are handled during the flushing process, so that possible adhesions on the oviducts and fimbriae are minimized. Indeed, present results do not indicate any serious postoperative reproductive problems.

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However, it would be desirable to develop simpler techniques of recovery that present no hazards to the reproductive potential of the donor. Considerable research has been done in the past on nonsurgical techniques of recovery. Recent Japanese reports (Sugie, 1973) indicate some success, but the rates do not seem to be high.

Future of embryo transfer

The dimensions of development in the embryo transfer field are multiple and exciting. The commercial realization of the technique is very likely to have a greater impact on research. The present technology indicates a trend of improvement and refinement. One important area which is actively researched by many investigators, including the writers, is the storage of embryos by freezing, similar to sperm preservation. Very promising success rates have recently been obtained with frozen mouse embryos (Whittingham *et al.*, 1972). Also, a live calf has been born from the transfer into a recipient cow, by researchers in Cambridge, England, of an embryo that had been frozen. The future in this area looks promising. Once bovine embryos are successfully frozen, banks can be established and the world can experience a new era of animal trade between countries. If embryos can be stored in a frozen state their immediate transfer becomes unnecessary. They can be transferred to the desired host animal anywhere and at any time. This could tremendously reduce present costs and make the practice accessible to many farmers.

In the meantime, it is possible that embryos can be shipped to other countries in a nonfrozen state, as it has been shown by the writers and others that they can survive under relatively simple laboratory conditions for as long as four days.

In vitro fertilization could be another area of development. The advantage here lies in the fact that the ovaries contain many more potentially viable eggs than can be utilized by the present system of *in vivo* fertilization. When abundant supplies of embryos become available from superior animals, even after slaughter, two could be transferred into one host cow, thus inducing artificial twinning which could have a great impact on meat production. Another possibility is the sexing of these embryos before transfer, so that the sex of the calf to be born can be predetermined. This has obvious implications in the dairy sector. It has also been shown that superovulation of immature females can be achieved; the resulting embryos when transferred to mature animals develop and grow into normal calves. A considerable shortening of the generation interval and the early progeny testing of females are indicated here.

These and possibly other developments in embryo transfer are expected to play a significant role in world animal production in the coming years, with substantial benefits for both developed and developing countries.

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MILK PRODUCTION FROM TROPICAL PASTURES

A reduced intake of digestible nutrients, particularly energy, is the principal cause of low milk production from tropical pastures

by T.H. STOBBS and P.A.C. THOMPSON

It is now established that well-fed *Bos taurus* cattle and their crosses are capable of high milk production in the tropics. Some of the best producers are found in the subtropical and tropical regions of Queensland in Australia and more dairying is carried out in this state than in any other comparable tropical or subtropical region in the world (Hayman and Radcliffe, 1973). However, yields from cows grazing solely on tropical pastures are low. Concentrate supplements are usually expensive and are often required for human consumption in many areas of the tropics. Therefore it is necessary to know the milk production per cow and per hectare that can be achieved from improved tropical pastures, to delineate the factors limiting production and to devise practical management systems to maximize production from these pastures. This article reviews these topics with particular reference to work conducted in Queensland.

Lactation yields of cows grazing tropical pastures

Milk production per cow from unsupplemented improved tropical pasture swards is markedly lower than from temperate swards fed at a similar stage of growth or from cows fed concentrate supplements. This is shown in Table 1, which summarizes the production levels obtained from Jersey cows grazing various tropical pasture swards in experiments in tropical Australia and compares them with production levels achieved from cows grazing temperate pastures and with animals receiving concentrate rations. Liveweight gain data are based on a compilation of production levels obtained in tropical environments.

Although individual cows grazing tropical pastures are capable of fairly

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high production, maximum daily yields of approximately 9-12 kg of milk per cow at the peak of lactation (or a total of about 100 kg butterfat through the lactation) are all that can be achieved from Jersey cows, even when grazing young, actively growing material. Friesians and other large dairy breeds are, however, capable of higher production because of their greater body size and higher feed intake. But in general the level of milk production per cow is low and below the genetic potential of the animal to produce milk.

Prediction of milk production

The prediction of likely levels of milk production from tropical pastures, using estimates of their chemical composition and digestibility as calculated from laboratory and animal-house studies, is not totally satisfactory due to the following reasons:

1. The animal's ability to select a more nutritious diet while grazing. The potential for selection is greater in tropical than in temperate pastures because of the large variation in nutritive value (nitrogen, digestibility, fibre and chemical composition) both within and between the leaf and stem components of tropical pasture swards.
2. The animal's ability to draw on body reserves for nutrients. Recent studies of the fatty acid composition of milkfat from cows grazing tropical pastures, particularly cows in early lactation, show a low proportion of short-chain fatty acids (C_4 - C_{16}) and a high proportion of oleic acid. This indicates that the energy content of the diet is inadequate and cows obtain energy from the catabolism of body reserves. Similarly, it has been found that a higher efficiency of feed conversion may be obtained during the dry season when pasture is in short supply and the cows then draw on their body reserves.

As a consequence of these factors, actual production levels are usually rather higher than the predicted levels. But even so, the differences in milk production between cows grazing tropical and temperate pastures (and those receiving concentrate supplements) are considerably greater than the differences in beef production under corresponding feeding regimes (Table 1). This suggests that milking cows are more demanding in their nutrient requirements than growing animals. Analyses of rumen fluid from animals grazing tropical pastures show a high proportion of acetic acid, but there is little variation in the proportions of volatile fatty acids when cows graze different tropical pastures. It would thus appear that differences in fermentation cannot account for the apparent differences in beef and dairy production. Preliminary results from experiments comparing production

"... there is considerable scope for selecting and planting species of higher feeding value ..."

Friesian cows grazing setaria-greenleaf desmodium pasture in north Queensland

from a range of pasture species using beef and dairy cattle rank feeds in the same order (Stobbs, 1973).

The effect of pasture maturity on milk production is recognized by every dairy farmer and, as far as is practicable, he attempts to feed young material. However, the digestibility of young regrowth rarely exceeds 70 percent. By selective grazing, cows can compensate to some extent for lower quality feed, but a stage is quickly reached at which quality affects production. It has been found that milk production from cows grazing Rhodes grass (*Chloris gayana*) was the same with three- and five-week regrowths, but milk production from cows grazing Kazungula setaria (*Setaria anceps*) was higher for the three-week regrowths (Hamilton *et al.*, 1970). It would therefore be desirable to develop pasture species for milk production which maintain reasonable quality to a later stage of maturity, even if this means sacrificing some herbage yield.

Milk production from various tropical species and cultivars

There is considerable variation between tropical pastures in their ability to supply nutrients for milk production when excess quantities of feed at the same stage of growth are provided. For example, three-week regrowth of pangola (*Digitaria decumbens*) has been shown to produce approximately 10 percent more milk than Rhodes grass, with Kazungula setaria giving an intermediate level of production. A recently conducted experiment (Stobbs, 1973) which compared three-week-old regrowth of four setaria cultivars (Nandi, Kazungula, narok and splendida) with pangola and Kikuyu grass (*Pennisetum clandestinum*) showed that cows grazing pangola and splendida (and to a lesser extent Kazungula) produced more milk than those grazing Nandi or narok and considerably more than those grazing Kikuyu. Forage crops such as forage sorghum, bulrush millet (*Pennisetum typhoides*) and white panic (*Echinochloa crusgalli* var. edulis) provide a considerable bulk of feed, but their quality when fed at semimature stages of growth is no better than perennial tropical pastures (Stobbs, 1975).

Voluntary legume intake

The voluntary intake by animals fed tropical legumes indoors is usually higher than that of tropical grass and hence higher milk production per cow would be expected. Thus, *Lablab purpureus* is able to maintain a relatively high production in contrast to tropical grasses (Hamilton *et al.*, 1970). Good milk production has been obtained from *Leucaena leucocephala* (Stobbs, 1972). *Trifolium semipilosum*-based pastures have proved to be quite outstanding, with milk yields from Jersey cows averaging 16 kg/cow/day over extended periods (Stobbs, 1973). However, lower milk production has been obtained from cows grazing pure stands of siratro (*Macroptilium atropurpureum*) and greenleaf desmodium (*Desmodium intortum*) than from nitrogen-fertilized pangola (Stobbs, 1971), possibly due to the difficulty cows have in harvesting the leafy fraction of the legumes. Pure stands of such trailing legumes are obviously not typical of farm practice and better production has been obtained from grass/legume mixtures, the legume being particularly beneficial in the early dry season.

Relatively free of toxins

As a group, the tropical pasture species are relatively free of toxins and other undesirable compounds (Hutton, 1971). The only tropical legumes known to have caused bloat are *Lablab purpureus* and *Trifolium semipilosum* and there is little evidence of oestrogenic activity. However, the oxalic acid content of a number of tropical grasses is high, particularly some *Setaria* spp. and some deaths from oxalate poisoning have been recorded. High oxalate in feed can depress butterfat content of milk. *Leucaena leucocephala* contains mimosine which reduces cell division and also acts as a depilatory, but with carefully controlled feeding it is not considered a major problem. Minor toxic effects have also been recorded on cattle grazing Kikuyu, and cyanogenic glucosides can cause death on *Cynodon plectostachyus* and sorghum pastures. Cows grazing some tropical legumes can produce milk with objectionable odours and flavour, the strongest occurring when animals graze *Lablab purpureus* and *Leucaena leucocephala*. Fortunately, these taints are lost on pasteurization. Some difficulty has been experienced in making cheese from milk produced when cows graze siratro, but feeding energy supplements overcomes this difficulty.

The poor nutritional quality of most tropical pastures not only results in low milk production per cow but also results in important changes in milk composition. When milk yield is depressed, the percentage of butterfat increases, and the percentage of solids-not-fat — particularly protein and casein — and short-chain fatty acids in milkfat decreases. Although these changes in milk composition are less important in tropical countries where fresh milk is usually the major requirement, such measurements are valuable for selecting herbage plants of high nutritive value.

Production per hectare from tropical pastures

Payne (1963) suggested that it should be possible on "good humid tropical pasture" to maintain five dairy cows per hectare, each producing at least 2 720 kg of milk annually. In fact, high-carrying capacities can generally be obtained on tropical pasture swards and the target of 13 600 kg/ha of milk was greatly surpassed by cows grazing heavily fertilized (672 kg N/ha), irrigated pangola pastures (Thurbon *et al.*, 1973) when mean yields of 17 400 kg/ha of milk were produced by Jersey cows and 22 400 kg/ha by Friesian cows, without any supplemental feed. High milk production per hectare has also been obtained from nonirrigated nitrogen-fertilized tropical pastures, particularly at high stocking rates (Colman and Holder, 1968; Caro-Costas and

Vincente-Chandler, 1969). However, Swain (1971) expressed doubts as to whether a viable dairy industry could be maintained in the tropics on legume-based pastures because of the low production per cow and per hectare. Although carrying capacities are generally reduced on grass/legume pastures compared with nitrogen-fertilized pastures, milk yields between 6 000 and 8 000 kg/ha have been recorded (Stobbs, 1972; Byford and O'Grady, 1973).

Reasons for low milk production

A reduced intake of digestible nutrients, particularly energy, is the main cause of low production. The protein content of tropical pastures is generally low by temperate standards and the concentration falls rapidly with pasture maturity. Trials in which energy and protein supplements are fed to cows grazing tropical pastures have shown that protein is less limiting than energy (Hamilton *et al.*, 1970). Studies of the composition of milk from cows grazing tropical pasture swards also suggest that the intake of digestible energy is the major factor limiting production.

The low digestibility of tropical pasture species at a relatively early stage of growth is one of the major causes of low milk production. Even temperate species grown in hot humid conditions have been shown to have a lower digestibility (Minson and McLeod, 1970) and therefore have a lower milk production potential.

The quality of dry matter voluntarily eaten by an animal is the most important factor controlling the productive value of a feed. The intake of pasture herbage is largely controlled by bulk in the rumen; the more rapidly the breakdown and digestion of feed proceeds, the faster the rate of passage (Thornton and Minson, 1973). It is therefore understandable that tropical herbages which are relatively low in digestibility have a low voluntary intake. Dairy cows grazing some tropical pasture swards, with low leaf yields and inaccessible leaf, can have difficulty in harvesting sufficient feed to maintain stable production. Grazing times on tropical pastures, particularly when trailing legumes and tall stemmy plants are present, have been shown to be excessively long (10-12 hr/24 hr) compared with an average of 6-7 hr/24 hr on higher quality temperate pastures. Animals are obliged to take small bites from some tropical pasture swards and they increase biting rate in an attempt to increase herbage intake. When cows have difficulty in satisfying their nutrient requirements, grazing is extended into the night; at certain times of the year over 50 percent of total grazing time is recorded between evening and morning milkings. The proportion of night grazing increases with the degree of heat stress. This emphasizes the need for good night-paddocks when grazing tropical pastures and is confirmed by increases in milk production achieved in practice.

How to get the best out of tropical pastures

With few exceptions, tropical pastures provide low to medium quality feeds for milk production and it is important to utilize these feeds to the best advantage. There is considerable scope for selecting and planting species of higher feeding value and, provided that these species are high yielding and persistent, considerable increases in production are possible. There is potential for improving milk production with better grazing management, particularly by grazing less mature herbage.

If increased output of milk from cows is desired, it will be necessary to feed concentrate supplements, although careful consideration of the economics of such feeding will be necessary. Energy supplements such as sorghum or molasses are mainly required, although in some circumstances protein supplements may be necessary. There is a tendency to say that a cow must have a certain amount of feed on a certain day because she is giving a certain amount of milk on that day. Since cows are continually building up body reserves or are milking off condition it is suggested that this process should be exploited in achieving the best use of feeds. Feeding should be considered over the whole lactation because there are periods when high quality feed is required and others when lower quality feed is adequate. There is no doubt that early lactation is the most important phase of the whole cycle: the cow's potential is being established and every attempt should be made to obtain a high peak yield. Tropical pastures are not sufficiently nutritious to meet the cow's energy requirements and it is highly desirable to feed concentrate supplements at this time. The cow's ability to respond to extra feed by giving extra milk falls gradually as the lactation proceeds. Well-managed tropical pastures are capable of reasonable levels of production once peak production has beeen achieved. Good quality tropical pastures do, however, allow animals to build up body reserves for the next lactation. Some steaming up with concentrates may be necessary for cows in poor condition and gains of 0.4 kg/cow/

TABLE 1. A summary of research findings on temperate and tropical pastures showing differences in digestibility and productivity

Diet	Dry matter digestibility	Maximum milk production [1]	Beef production liveweight gain
	Percent	*Kg/cow/lactation*	*Kg/day*
Tropical pasture			
1. Immature	60 - 65	1 800 - 2 200	0.7 - 0.9
2. Semimature	50 - 55	1 000 - 1 400	0.4 - 0.5
Temperate pasture . . .	70 - 80	3 300 - 3 800	0.9 - 1.2
Concentrate ration . . .	80 - 85	4 400 - 4 900	1.2 - 1.4

[1] Jersey cows.

Jersey cows grazing Lablab purpureus *in southeastern Queensland*

day or more are desirable to allow for growth of the foetus.

It can be concluded that cows grazing improved tropical pastures are capable of milk production up to about 2 000 kg per lactation. Despite being fibrous feeds of low digestibility, tropical pastures are capable of producing good liveweight gains and there is considerable scope for integrating such pastures into dairy feeding programmes.

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Potential for by-product feeding in tropical areas

by P.B. O'Donovan

Efficient livestock production depends a great deal on sufficient feed of the right quality being available throughout the year. During the rainy season in tropical areas there is usually enough pasture for feeding ruminant livestock; the success or failure of livestock enterprises depends on feed supplies being available during the dry season when little or no grass grows.

Large quantities of various by-products are usually available in the tropics during the dry season. In some areas they are discarded or only partially used, and valuable sources of potential feed are lost. In others there may be a total dependence on by-products for dry-season feeding; if well planned this system can be satisfactory, but it is usually difficult to maintain a continuous supply for the entire period. In still other areas, by-products may be used in addition to feed conserved as silage and hay; if some herbage growth occurs animals may be grazed for a limited number of hours a day and their additional requirements met with conserved feed or by-products. Where there is little or no herbage growth, feeding systems may be based on conserved feed or by-products, or a combination of the two. Local conditions will determine which system is the most practical and economic. Some of the more important by-product feeds available in tropical areas are discussed in this article.

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Sugarcane is widely grown and is an important source of income for many countries. The processing of sugarcane yields a number of important by-products for animal feeding.

Sugarcane by-products

MOLASSES

Molasses is a valuable source of energy, and is often either underutilized or exported at a low price. When used for livestock feeding, frequently much less than its maximum value is obtained because it is fed with unsuitable ingredients and in unbalanced diets. It has long been known that the inclusion of a small percentage of molasses improves the palatability of the diet and it is particularly valuable when incorporated with coarse unpalatable roughages. Lofgreen and Otagaki (1960a, 1960b) found less net energy in mixed diets containing more than 10 to 15 percent molasses, although this varied with total feed ration composition. Hatch and Beeson (1972) reported that replacing 5 percent rolled maize with molasses in rations had no apparent effect, but 10 and 15 percent replacement increased nitrogen retention; both energy and dry-matter digestibility and butyric acid in the rumen were significantly increased by the higher molasses percentages. Because of the large quantities of cane molasses produced in tropical areas, it is important to explore the possibility of using higher than conventional levels. Reports indicate (Preston *et al.*, 1967; Elias *et al.*, 1968) that molasses may comprise up to 80 percent of the metabolizable energy for beef cattle under specific feeding conditions. In these studies the fresh forage allowance was restricted and fish meal supplied the additional protein. The animals had free access to molasses/urea in troughs and daily liveweight gains ranged from about 700 to 900 g.

O'Donovan and Chen (1972) fed dairy heifers at different stages of growth on diets in which cane molasses accounted for 25, 33 and 45 percent of the total weight of feed (Table 1). The animals gained weight satisfactorily on the first two levels, but the 45 percent molasses diet, which contained only 10 percent soybean meal, significantly depressed rate of gain. Results indicated that growing heifers could initially be fed 25 percent molasses and the level could later be increased to 33 percent. In the latter diet two by-products, rice straw and molasses, accounted for 68 percent of the total weight of feed. Liveweight gain can be regulated by increasing or decreasing the percentage of straw fed.

BAGASSE

Conventional bagasse contains two fractions: an outer portion called the rind and the finer inner part known as the pith. Millions of tons of bagasse are produced in sugarcane factories, and a significant percentage is burned as fuel; thus a potential source of animal feed is not fully exploited.

Bagasse *per se* is a low-quality feed, principally because of its high percentage of lignocellulose. When

Various by-products suitable for livestock feed are usually available in large quantities in the tropics during the dry season — in some areas these are discarded or only partially used

During the sugarcane harvest the leaves are traditionally fed to draught animals. Here, buffaloes are taking a midday break from helping with the harvest and are feeding on the leaves. However, the use of this by-product can extend well beyond such traditional practice.

mixed with protein and a source of energy such as cane molasses, moderate levels of bagasse can promote satisfactory liveweight gains. Levels higher than 30 percent by weight tend to depress rate of gain.

The treatment of high-fibre materials (cereal straws, bagasse and wood pulp) with sodium hydroxide or steam significantly increases digestibility. These possibilities have been discussed by Pigden (1971). Even if chemical treatment does not become a commercial reality, much can be achieved by feeding untreated bagasse at optimum levels in mixed rations. Since bagasse and molasses are usually available in combination, there is a great potential for feeding these in the correct ratio with supplementary protein and nonprotein nitrogen. Where less than maximum gains are required, by-product mixtures are useful in maintaining livestock or promoting a low rate of gain among beef animals during the dry season.

Sugarcane leaves

At harvest, sugarcane leaves are burned or otherwise separated from the cane. If they are not burned they may be collected and made into bundles to facilitate transport from the field. To maintain a high feeding value, they should preferably be collected on the day of harvest when they are still green. The feasibility and economics of collecting the leaves vary from one region to another. Where labour costs are low, they provide a cheap source of feed. The leaves should be chopped to facilitate feeding and to avoid rejection of the fibrous parts.

O'Donovan (1970) fed chopped sugarcane leaves, containing 5-6 percent crude protein, to a herd of commercial dairy cattle and to beef cattle. This feed was found to be sufficient to meet the maintenance requirements of dairy cattle and to provide for the production of about 2 kg of milk per cow — a production level which could scarcely be realized with average quality pangola grass silage. With beef cattle, maintenance requirements were met and an average daily liveweight gain of 0.25 kg was obtained. It was found necessary to feed more protein and energy in order to achieve higher rates of gain.

If mechanized harvesting becomes more widespread, the bulk collection of the leaves may be possible. There is evidence that satisfactory silage can be made from the chopped leaves; this is a convenient method of conserving the surplus for subsequent feeding.

Sugar factory residue

In certain regions there is a residue of sugar extraction consisting of a mixture of the first froth of boiled cane juice and fine bagasse or pith, mixed in a ratio of about 5 to 1. Its approximate composition, on a dry-matter basis, is 11-12 percent protein, 26-35 percent fibre, 1.4 percent Ca and 1 percent P. This residue, called *cachaza* in Cuba, is used mainly as organic matter for soils. Its rather high phosphorus content could be an advantage if it is fed to cattle when herbage P contents are low. This was tested in Cuba, where the fresh residue was incorporated in mixtures (with molasses) and fed to beef cattle on pasture for part of the dry season. The mixtures were consumed without difficulty and the inclusion of the residue did not significantly depress the rate of liveweight gain. Animals fed the mixtures had higher levels of serum phosphorus.

Because the residue has a low dry-matter content (about 25 percent), moulds grow rapidly on it in hot humid conditions. Economic considerations are likely to rule out drying, so that it is necessary to utilize the material in fresh form. It must therefore be fed in close proximity to sugar factories. There is little information as yet concerning its real value as a livestock feed. The extent to which it will be fed to livestock will also depend on alternative sources of better quality feed.

Rice straw

The value of rice straw as a roughage feed for ruminants has never been fully exploited, although traditionally it has been used for feeding buffaloes and zebu cattle in many areas. Its true potential has not been realized for two main reasons: (*a*) only a fraction of the total rice straw produced is fed to animals, the remainder being used for the manufacture of paper or ploughed into the soil or burned; (*b*) the rice straw used for feeding is offered with little or no supplements (energy, protein and minerals) and this results in very poor utilization.

Rice straw is nutritionally comparable to barley and wheat straws, and in some cases may surpass these. Its nutritive value is influenced greatly by the stage of harvesting; the protein content is higher if it is harvested when it still retains some of its green colour, when it compares favourably with poor to average hay made from tropical pasture species. Straws are consumed in small amounts when they constitute the only feed. There is ample scope for feeding rice straw in tropical areas, and its potential is enhanced by the availability of cane molasses as a readily available source of energy. A starchy feed ingredient and protein are also needed. The latter may be fed in part as true protein and in part as urea.

O'Donovan and Chen (1972) fed growing dairy heifers with rations in which chopped rice straw comprised 25 and 35 percent of the total mixture, the remainder consisting of cane molasses, sweet-potato chips, soybean meal and urea (Table 1). Daily liveweight gains ranged from 460 to 820 g, the former level reflecting a low soybean content in the ration and the depressing effect of 45 percent cane molasses. Satisfactory gains were obtained when all the feed ingredients, except soybean meal, were home grown and about two thirds of the entire ration consisted of rice straw and molasses.

Pineapple bran (pulp)

Pineapple bran (more aptly described as pulp) consists of the skin and often the core of the pineapple, and accounts for an estimated 40-50 percent of the total pineapple weight. Because of its rather high fibre content, the bran is more suitable for ruminants than for monogastric animals. The net energy values of pineapple bran and pineapple hay are reported to be 118.8 and 85.8 Mcal/100 kg (Otogaki *et al.*, 1961). Fresh pineapple bran usually contains only about 10 percent dry matter, and because of this it is more convenient to feed it in the vicinity of the factory during the canning season. Long-distance transport is both difficult and expensive. However, if pineapple bran is needed elsewhere for feeding, it is possible to employ such techniques as drying (either in the sun or using a conventional dryer) and conserving as silage, in which case the fresh bran is mixed with other ingredients with higher dry-matter content.

O'Donovan, Chen and Lee (1972) investigated a number of pineapple bran silage mixtures (Table 2). Those incorporating molasses or molasses and a source of starch (maize and sweet potatoes) fermented satisfactorily, and it was possible to formulate a wide variety of suitable mixtures, bearing in mind the importance of silage-making and fermentation principles. Partial or complete sun drying is possible, but it is hazardous during the rainy season.

Citrus pulp

Citrus pulp is a by-product of citrus canning, and it contains about 25 percent dry matter. Many of the considerations relating to pineapple bran apply also to citrus pulp. Surplus quantities of pulp may be conserved as silage when mixed with other ingredients such as molasses, urea and bagasse. A variety of these ingredients may be used, the aim being an end-product sufficiently high in dry matter; molasses supplies readily available energy for fermentation. There should be little difficulty in formulating a number of suitable mixtures for animal feeding.

Citrus pulp can also be sun-dried or drum-dried, permitting storage for subsequent feeding. The latter method, however, is expensive when large quantities of liquid have to be removed and may increase the cost beyond that of other more valuable ingredients. The aim should be to utilize the material without undue

processing costs. For this reason the use of fresh or ensiled material seems to offer the best possibilities. Citrus pulp has an important future in livestock feeding, as evidenced by a number of experiments. A review of experimental work at the University of Florida (Chapman *et al.*, 1972) indicated that dried citrus pulp can comprise up to 40 percent of the concentrate ration with excellent results. This is supported by the findings of Bhattacharya and Harb (1973) in studies with Awassi lambs; the digestion coefficient for energy was highest when citrus pulp was incorporated at a level of 40 percent in mixed diets. Satisfactory gains were obtained with fattening cattle when 70 percent of the concentrate portion of the diet consisted of citrus pulp (Carnevali *et al.*, 1972). A feeding trial was conducted in Cuba (unpublished data) where growing steers were fed 3 kg per day of one of two concentrate supplements; where 25 percent cane molasses was replaced by dried citrus pulp, significantly increased daily gains resulted.

There appears to be little doubt as to the value of citrus pulp in ruminant livestock rations. Finding the most practical and economic means of utilizing it in areas where there are large supplies deserves priority.

Sweet potato haulms

Sweet potatoes are an important crop in many areas of the tropics and are a source of animal feed as well as human food. The haulms have not received deserved attention as a feed for ruminants, although they are fed in some countries to buffaloes and zebu cattle. They are available during the dry season when feed supply is usually critical.

Sweet potato haulms were fed to dairy cows with good results by O'Donovan (1970). They invariably increased milk yields when succeeding a diet of sugarcane leaves or silage, principally because of their higher protein content. The haulms were consumed avidly and there were no noticeable ill effects. They may supply part of the feed for dairy and

Above: High-grade Holstein heifers receive a diet in which rice straw and molasses — two widely available by-products in tropical areas — constitute more than two thirds of the total.

Left: Small quantities of pineapple bran silage mixtures were evaluated in a pilot test. The darker colour of the mixture on the right indicates better preservation.

Below: Santa Gertrudis crossbred cattle, which performed satisfactorily on a diet that included 70 percent dry pineapple bran, are shown in the early stages of the test.

beef cattle, especially in countries where labour costs for collection and transport are not too high.

Use of urea in by-product feeding

Lack of protein is often the most important limiting factor in the feeding of by-products. Nonprotein nitrogen in the form of urea is now available in increasing quantities in many developing countries, and could help overcome this limitation.

Research in developed countries provides information on conditions under which urea may be utilized for ruminant feeding. Work by Virtanen (1966) suggested that urea could supply all the dietary nitrogen in semipurified diets for cows and could at the same time support high milk yields. Later work (Virtanen and Ettala, 1969) showed that higher yields resulted when some true protein was present. Recommendations from the United States are that urea may replace a maximum of one third of the dietary nitrogen. Comparisons indicate that the response from urea (in terms of daily liveweight gains and milk production) has approximated but rarely exceeded that from soybean meal.

Research in the arid areas of the world has shown a variable response to urea when the aim is to increase the nitrogen intake of animals consuming low-protein roughages (FAO, 1971). A review of the subject by Loosli and McDonald (1968) illustrates the variability in results when experiments are conducted under widely different conditions. While urea is beneficial in alleviating a large weight loss, it has rarely promoted gains without the presence of some energy feed.

The application of urea feeding in the tropics is of considerable importance. Hsu (unpublished data) fed milking cows restricted amounts of green forage in addition to a mixture of cane molasses, sweet-potato chips and urea; the latter supplied 55-65 percent of the total nitrogen. A steady decline in milk yields was partially averted by replacing 2 kg of sweet potatoes in the ration with ground maize — a response which may be attributed to the additional protein. O'Donovan, Liang and Chen (1972) compared urea with soybean meal in concentrates for milking cows under zero-grazing conditions (Table 3). Urea supplied about 50 percent of the total dietary nitrogen. Although 8 percent less milk was produced, the results were encouraging. Economic considerations may take priority in some areas: it could be expedient to accept a small decrease in milk yield by using a cheap local source of urea nitrogen rather than import expensive protein.

Evidence is still lacking regarding the successful use of very high levels of urea for animal feeding under tropical conditions. Urea may supply a

TABLE 1. Rations containing different percentages of cane molasses (rice straw as roughage) and daily liveweight gains when fed to growing heifers

Ingredients [1]	Ration A fed to heifers weighing 132-182 kg	Ration B fed to heifers weighing 182-205 kg	Ration C fed to heifers weighing 205-310 kg
		Percent	
Rice straw, chopped	25	35	35
Cane molasses	25	33	45
Sweet-potato chips, dried	30	18	10
Soybean meal	20	14	10
		Grams per kilogram	
Urea	20	20	25
		Percent	
Crude protein	16.0	13.7	13.5
		Kilograms/day	
LIVEWEIGHT GAINS:			
Test 1	—	0.58	—
Test 2	0.71	0.82	0.46

SOURCE: O'Donovan and Chen, 1972.
[1] All rations fortified with bone meal, salt and vitamin A.

TABLE 2. Ingredients of six pineapple bran silage mixtures

Ingredients	Silage mixtures [1]					
	1	2	3	4	5	6
			Percent			
Pineapple bran, wet	75	65	75	65	65	82.5
Rice straw, chopped	10	20	10	20	20	7.5
Maize meal	15	15	5	5	—	—
Cane molasses	—	—	10	10	15	5.0
Sweet-potato chips, dried	—	—	—	—	—	5.0
Urea (additional)	1.0	1.0	1.5	1.5	1.5	
Percentage dry matter	28.8	36.2	27.6	35.2	34.6	26.2

SOURCE: O'Donovan, Chen and Lee, 1972.
[1] Mixtures 1-5 in small plastic bags; mixture 6 in small silos.

TABLE 3. Composition of soybean meal and urea mixtures fed with roughages, and milk yields obtained

Ingredients [1]	Soybean meal mixture	Urea mixture
	....Percent....	
Sweet-potato chips, dried	25	50
Maize, ground	15	25
Cane molasses	25	25
Soybean meal	35	—
Urea	—	*g/kg* 50
MILK PRODUCTION [2]		
Total yield (*kg*)	2 782	2 371
Average yield (*kg/day*)	12.4	10.6
Average decrease (*kg*)	3.2	4.1

SOURCE: O'Donovan, Liang and Chen, 1972.
[1] Bone meal and salt added. — [2] From 28 to 224 days of lactation.

maximum of 50 percent (ideally somewhat less) of the total dietary nitrogen.

Role of by-products

Only a few of the many by-products that can be exploited in tropical areas for animal feeding have been discussed in this article. They should not be regarded as providing a complete solution to livestock feeding problems generally, but rather as filling a gap in meeting overall requirements. Although by-product mixtures can be employed in intensive animal production systems, they are used to best advantage during the dry season when feed is in short supply; thus, they can provide for maintenance and low levels of production until pasture starts growing again. Full utilization of by-products can only be realized when they are appropriately combined to form balanced diets.

In many tropical areas there is competition between livestock producers and industry for certain by-products. This competition may proceed to a point where industry can afford to pay a higher price than the livestock producer, who must calculate the costs according to the nutritive value of the material. An example is the utilization of rice straw for the manufacture of paper; the production of alcohol from molasses is yet another, while the lack of fuel in some areas may lead to the use of sugarcane bagasse for this purpose.

Despite this competition, by-product feeding can be of great importance in livestock systems where the problem is largely one of uneven feed distribution: a rainy season with much herbage growth and a dry season with little or no growth. Where conserved herbage (hay and silage) is not available, by-products are often the only source of feed in the dry season. For each area it is necessary to determine the months of the year when these become available and what mixtures may be employed. Conserving the surplus by drying, ensiling or other means ensures a continuous supply of fresh and conserved feed over a prolonged period. Judicious use should be made not only of by-products but of all other feed resources as well.

It is encouraging that there is a move toward the establishment of regional research stations in different parts of the world. This should lead to more coordinated research on common problems. Results obtained with by-product mixtures would be similar within a given area, thus obviating the duplication of research effort. There is need to investigate further the feeding value of by-products and by-product mixtures, in particular those of sugarcane, rice, pineapple and citrus.

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LIVESTOCK PRODUCTION SPECIALISTS

one system for training in the lowland tropics

It is not necessary to spend time justifying the worldwide need to increase food production. Volumes have been published showing that food production is not keeping up with population growth. The developed countries are producing less food for exportation, as their populations continue to grow and more land is removed from agriculture and used for housing, schools, transport, recreation, and so on.

Developed countries are able (in most years) to maintain production levels by becoming more efficient. A few years ago, one United States farmer fed 7 people, today he feeds approximately 40. In the future, developing countries will receive less aid from more advanced countries in terms of food imports, so that they will have to produce their own food locally. As most parameters of livestock production in developing countries are 30 to 50 percent below those of developed countries, there is scope for increases of great magnitude. In fact, data from various countries in the tropical zones of Latin America, Africa and Asia show that growth rate, weaning rate, reproduction rate and milk production have been increased to levels comparable to the production of more advanced countries, not only in experimental stations but in commercial operations. This clearly demonstrates that much of the technology (either locally developed or adapted) necessary to bring about a revolution in meat and milk production already exists.

Many scientists have long believed that great advances in technology will be put into practice automatically. This fallacy has led to a great time lag between the development of technology and its implementation. The scientists cannot be held responsible for this failure, as they are fully occupied with research and, at best, can only be expected to keep their research efforts directed toward solving the most urgent problems. Training efforts to date for developing countries have been focused on preparing students to develop technology. Now is the time, if it is not overdue, to train people in the transfer of technology to the farmer.

Production specialists

For many countries the livestock production specialist is nothing new, but in most developing countries there are few people who can serve effectively as the "change agent" for the transfer of technology from the experimental plots to the farmer's field.

The people most often in contact with the farmer, and responsible for bringing about technological change, are usually recent college graduates with limited field experience (many have no farm experience) and almost always trained to be specialists rather than generalists. Another reality in developing countries is that scarcity of adequately trained people, coupled with lack of infrastructure, communication systems and local transportation, isolates the farmer from frequent contact with specialists of various disciplines. This situation therefore accentuates the need for a production specialist.

A production specialist would be sufficiently trained in areas such as soil and water management, feed production and preservation, animal nutrition, management and health, farm management and economics, and communication skills, to the extent that he could identify problems limiting production. He would then be supported by discipline specialists when needed, and this would allow the latter to serve a larger area by more efficient utilization of their resources.

CIAT training programme

In 1970 the newly established International Centre for Tropical Agriculture (CIAT)[1] began, as one of its areas of training, a one-year course

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[1] Centro Internacional de Agricultura Tropical, Colombia.

by
C. PATRICK MOORE

Trainees learn traditional systems of animal restraint

in tropical livestock production with the objective of enabling the trainee:

1. To assimilate and integrate the broad spectrum of scientific disciplines and technologies in order to achieve efficient and economical livestock production.
2. To develop his imagination, powers of observation and logical reasoning as the basis for "pragmatic innovation" which will provide producers with a wider range of management options.
3. To aquire investigative skills sufficient to evaluate the literature and develop more productive systems and better resource utilization in harmony with the native environment.
4. To acquire the knowledge, desire and field experience to become an efficient communicator with his colleagues, students and the livestock producer.

Selection

Before being accepted, each student is interviewed by a member of the CIAT training staff in his country (within Latin America). Standard prerequisites for candidates are: completion of a college degree in agriculture, active employment by a national agricultural agency which must guarantee future employment after the course is finished; good health. No discrimination in selection is made between veterinarians, animal husbandmen and agronomists. Ideally, candidates should be native to and working in the lowland tropics, as they are less likely to suffer climatic and cultural shock during the course and are more likely to return to a tropical area to work.

Phase I (basics)

During the first three months the trainees are housed at the centre and divide their time between classroom lectures (60 percent) and field practice (40 percent). Approximately 95 percent of the lectures/labs are given by the CIAT scientists, as the various subjects relate to their field of expertise. Guest scientists are invited from neighbouring institutions to cover the remaining subjects. Classroom activities are not formal lectures but rather discussion sessions with the professor acting as moderator and supplying basic information as needed, always keeping the discussion on the solving of livestock production problems. The laboratory exercises are designed to develop the trainee's abilities in the areas of basic plant and animal management in the field and to train him sufficiently to enter the second phase of the course. Subjects covered during these three months in the classroom and in the field are as follows:

1. Beef cattle husbandry
2. Social sciences
   a. Agricultural economics
   b. Library science
   c. Communication
   d. Rural development
   e. Farm management
3. Monogastric nutrition
4. Swine production
5. Animal health
6. Pasture and forage production
7. Statistics
8. Ruminant nutrition
9. Equine husbandry
10. Soil management

11. Pasture weed control
12. Minor species husbandry
13. Human nutrition and first aid
14. Family vegetable production
15. Farm machinery.

Obviously, all subjects do not receive equal time and some are dealt with in a general manner, according to their relative importance within a family livestock production unit. It should be noted that considerable emphasis is given to the social sciences, subjects which, without exception, are found to be those in which trainees are most deficient.

PHASE II (RANCHING)

After completing three months of preparatory training at the centre the trainees are moved to the Atlantic coast of Colombia (a large cattle-producing region), where they are situated in commercial beef cattle ranches and live for eight months under the constant supervision of the leader of the programme and three training assistants.

The ranchers who collaborate with the training programme are selected by the training staff according to the following criteria:

— Their willingness to provide adequate room and board for the trainees.

— Their expressed desire to improve their ranching operations.

— Ranches must be accessible by jeep throughout the year.

— Ranching operations should be concentrated on cow-calf production.

— Ranches should be close enough to the training centre to allow the constant supervision of the trainees by the training staff.

Identifying collaborators has been no problem, as they realize that their contribution to the training programme is well worth the benefits they receive in terms of improvements left behind by the trainee. Experience has demonstrated that working with a rancher who has a development loan is much more productive for the trainee, as he is involved in the changes brought about by the nature of the loan. Future training programmes will give priority to ranches that have development loans.

animal health and nutrition

Classroom demonstration

Necropsy in the field

pasture and forage

Establishment of tropical legume and grass pastures

Weed control demonstration

The first month is spent making an inventory/analysis of the ranch, including land, labour, capital, animal population, forage species, production parameters, and other factors related to production. After completing this analysis the trainee, together with the training staff and the ranch owner, develops a plan of improvement which has both short and long-term implications.

The remaining seven months are spent implementing the basic plan as much as possible and preparing groundwork for the longer range programme. Each trainee is also required to design and complete at least one small replicated trial on the introduction and/or testing of new technology at the ranch level. Some of the fields in which the trainee can begin immediately are: the development of animal health and management programmes, sanitation control, establishing a record-keeping system, fence building and pasture division, animal identification, pasture evaluation, weed control, soil analysis, animal reproduction and the development of a farm management calendar. Other projects, such as breeding programmes, improving reproductive efficiency and pasture improvement, require a longer time to establish and the trainee can only initiate them during his stay at the ranch. The programme provides the trainee with the equipment necessary for his work and for demonstration trials. Normal drug requirements — vaccines, herbicides, insecticides, etc. — are provided by the ranch owner.

In addition to ranch activities, every other weekend the trainees gather at a field station where problems and work plans are discussed with CIAT and/or other invited staff members from local institutions. Visits are also made to other ranches, slaughterhouses, cattle markets, diagnostic laboratories and research stations to acquaint the trainees with the many institutions involved in livestock production. Each trainee also spends one week teaching a selected short course at a nearby vocational school, where the pupils are teenagers with limited education being prepared for jobs as ranch foremen.

At the end of the eight months each trainee organizes a field day for his ranch. This requires the preparation of charts and graphs, biological materials for display, and demonstrations on animal management, pasture improvement, weed control, forage preservation, etc. Neighbouring ranchers and other trainees and professionals working in the region are invited. This not only forces the trainee to review his activities over the past eight months, but gives him the opportunity of communicating his experiences using various types of media.

PHASE III (EVALUATION)

The final month is spent at the centre, where the trainees' work is evaluated. Each trainee spends one week writing a report on his activities during the ranch phase, including all observations and suggestions related to the ranch. Trainees learn from each other that even ranches within the same area have different kinds of problems.

A series of round table discussions, arranged by disciplines, is held among the trainees and the scientists. This gives the trainee an opportunity to ask many questions stimulated by his living on a ranch, and also serves to update the scientists on the current problems and concerns of the livestock producer. This exercise may be more useful to the scientist than to the trainee, as the scientist is presented with new problems or new ways of looking at old problems.

The students evaluate the quality of the course itself in relation to its contents and execution. Having gone through this experience, they develop and discuss plans for preparing livestock production specialist courses in institutions in their own countries, relative to their individual needs and available resources.

In addition to the training materials that the student receives throughout the course (lecture handouts, manuals, bulletins, etc.) he is given selected books, slide sets and in some cases vegetative material at the end of the course to take back to his own institution for training purposes.

communication and demonstration

Field day for neighbouring ranchers

Trainees presenting data collected in their ranches


Demonstration of long-span fence


Animal restraint and identification

Conclusions

To date, participants from 10 Latin American countries have received 47 man-years of livestock specialist training in CIAT. This is an insignificant figure in comparison to the need. To achieve a multiplier effect, CIAT had hoped that many of these men would be placed in training positions in their own institutions; generally this has not occurred as most graduates are given direct technical assistance jobs which offer little opportunity to train other production specialists. A positive note is that alumni from two universities are actively leading in-field livestock production training programmes at the undergraduate level — where it logically belongs.

The institutionalization of this type of training in established universities is quite as difficult as the changing of traditional agriculture itself. If it is agreed that the latter must change in order to increase food production, then the present system of training young professionals in production must change first.

There is nothing sophisticated or new about this system of training; but it is a step that is being left out of the preparation of most of the young professionals who are responsible for bringing about improvements in livestock production. It requires competent instructors who are dedicated to training young production specialists, and who are not afraid to combat the elements of the humid tropics to do so. The farmer's basis for reasoning and making decisions cannot be taught in the classroom, and until the technical adviser understands his clients, and their problems and frustrations, he will not be able to communicate effectively with them or bring about change. We cannot wait for this rapport to develop through costly years of experience, but we can concentrate the same experience into a much shorter time period. This can only be done if more people (influential people) become more concerned and involved in improving the training process for the students of today who must feed the world tomorrow.

A HERD OF BRAHMAN CATTLE IN THE PHILIPPINES

The low productivity of cattle in the Philippines has been attributed in the past to the insufficiency and poor quality of the forage that the natural grasslands produce. In order to overcome this the Government launched a programme (National Cooperative Pasture Resources Development Programme) which coordinates the fragmented efforts of the public and private sectors in developing a functional livestock industry. It is encouraging to note that over the past few years a slow but steady expansion of improved pastures has taken place.

One of the pioneer enterprises in this field is the Ansa Cattle and Crop Farm. Less than 12 years ago this 2 000-hectare ranch in the southern Philippines was an expanse of native grassland and forest. Today it is a fine example of how beef cattle can be successfully raised in tropical Asia on properly managed grass and legume pastures. Nearly 3 000 head are maintained annually in the Ansa operation, which was set up in 1963 and began with 100 head in 1964. In 1966, 45 purebred American Brahman cattle were purchased from the J.D. Hudgins Ranch in Texas, United States, together with 69 grade bulls and 435 grade-zebu heifers. With additional imports of purebred Brahman stock, and local purchases, the Ansa herd at the end of 1973 included 765 purebred American Brahman cattle and 2 210 head of commercial cattle composed mainly of crosses of zebu with indigenous strains.

Location

The Ansa farm is located at an altitude of 730 metres on a 2 000-hectare plateau at the foot of the Kiamba mountains. The predominant soil is a sandy loam with high organic matter and an average pH value of 5.7. About 600 hectares are level, 450 hectares are undulating and 800 hectares are rolling land; the remainder are hilly. The entire site is crisscrossed by creek beds and gulleys which provide excellent drainage. Rainfall is more or less evenly distributed throughout the year, with an annual average of 2 300 mm. Temperature range is from 18°C to 24°C, humidity is rather high owing to the elevation and the influence of heavy precipitation.

The original vegetation consisted mainly of cogon grass (*Imperata cylindrica* L.), ferns, bushes, bamboos and other species characteristic of secondary growth forest. Native grasses and ferns have been weeded out in some areas and the land planted to tropical grasses and legumes. Parts of the land under cogon grass have been seeded to superior legumes. The pasture improvement programme involved planting grass-legume combinations at the rate of 100 hectares per year until the total area planted reached 1 500 hectares. Some of the grass-legume combinations that have been found best adapted to the locality are napier-centrosema, napier-desmo-

Group of Philippine-born purebred American Brahman yearling heifers

First-cross cows with their three-quarter bred calves

dium, para-centrosema and Kikuyu-centrosema. Other improved forage species planted on a limited scale include the grasses setaria, buffel and guinea, and the legumes siratro, Townsville lucerne and silverleaf desmodium.

Fertilizer

Total fertilizer needs for the improved pastures are divided into three applications a year. Pastures are mowed once a year to keep down weeds and encourage young, palatable regrowth. The fertilizer combination adequate for grazing purposes was found to be in the ratio of 60-45-45 of N-P_2O_5-K_2O per hectare per year, while a higher proportion of nitrogen (ratio of 120-75-75) was applied for silage and soilage (cut fodder) purposes.

periods of soilage scarcity the cattle are fed grass-legume silage.

Performance characteristics

Bulls generally weigh from 800 to 1 100 kg. The calves are small at birth, weighing from 27 to 35 kg, but grow very rapidly. With proper nutrition and good management, there have been no serious problems from pests and diseases with Brahman cattle at the Ansa farm. Fertility has been at a high level. The calf crop is 89 to 94 percent for the purebreds, compared with 75 to 83 percent for the upgraded commercial herds.

A one-year grazing trial using replacement heifers on napier grass (*Pennisetum purpureum*)-centrosema (*Centrosema pubescens*) pasture produced an

Imported purebred American Brahman foundation sire at the Ansa Cattle and Crop Farm

The breeding herd is run on pasture for the whole year. Brahman cattle thrive well on tropical grass-legume pastures and mineralized salt supplement. However, breeding bulls need to be rested for a few months and are given concentrate supplements during their "recharging period." The same feeding programme is followed for the commercial herds, whereby the calves are allowed to run with their dams on pasture until weaning. Weanlings are transferred to feedlots, and after performance testing (in terms of rate and efficiency of weight gain) are run again on the range. Slaughter and culled animals are fattened with a 10 percent protein concentrate supplement, equivalent to 1 percent of body weight, besides the regular silage which is given *ad libitum*. During limited

average daily gain of 0.47 kg. On para grass (*Brachiaria mutica*)-centrosema pasture, F_1 steers made an average daily gain of 0.49 kg, while those grazing on native pasture gained 0.25 kg per day.

The fact that these weight gains were achieved on tropical pastures, with mineralized salt as the only supplement, demonstrates that Brahmans and their crosses are well suited to tropical grassland farming. By improving pastures and fertilization liveweight gain is increased, and so is the carrying capacity of the pastures. Trials conducted at Ansa and other ranches have shown that tropical pastures could carry up to five animal units per hectare without affecting weight gain. The provision of supplemental feed during the dry season would further increase carrying capacity.

The chief asset of the Brahman is its ability to produce red meat economically. In the Philippines, the first data available showed that the type of pasture greatly affected the carcass yield and quality of Brahman crossbred steers. Carcass yield of steers fed on native pasture was 50.5 percent, compared with 54.9 percent for steers grazing improved tropical grass-legume pastures. Carcass grades were respectively "Utility" and "Good" for steers grazing native and grass-legume pastures.

A. NOCOM, general manager of the Ansa Cattle and Crop Farm, Makati, Rizal, Philippines.

Symposium on cattle production

The twenty-third Easter School in Agricultural Sciences to be held from 14 to 17 April 1975 at the University of Nottingham School of Agriculture, Loughborough, United Kingdom, is being organized by Dr. W.H. Broster (National Institute for Research in Dairying) and Dr. H. Swan (University of Nottingham), and will be concerned with cattle production. It is designed as a symposium to integrate recent developments in the scientific disciplines which can be related to practical cattle production. The five sessions will be devoted to developments in cattle physiology, the influence of rumen function on ruminant production, food requirements and utilization, practical cattle nutrition, and cattle breeding.

Further information may be obtained from:

Dr. H. Swan,
University of Nottingham School of Agriculture,
Sutton Bonington,
Loughborough, Leics. LE12 5RD,
United Kingdom

Twenty-first European Meat Research Congress

The twenty-first European Meat Research Congress will be held at the conference centre in Berne, Switzerland, from 31 August to 5 September 1975. The four working days will be devoted to: biochemistry, physiology of nutrition; microbiology, hygiene, residues; production, packing, technology; additives, flavouring and control. During the congress there will also be an international exhibition on "Meat as a foodstuff."

The address for applications is:

Official Tourist Office and Convention Bureau of the City of Berne,
Main Railway Station,
P.O. Box 2700,
CH-3001 Berne, Switzerland

UNITED STATES PRODUCTION OF SOYBEANS AND SOYBEAN MEAL IN 1974/75

Protein supplies to meet expanding world demand have been erratic in recent years and the 1974/75 season is no exception. A wet spring delayed planting of soybeans in the United States. Drought during the growing season sharply reduced potential yields, and early killing frosts further cut prospects for soybean production. As of 1 November, the forecast of United States soybean production was 33 855 000 metric tons, an expected outturn about 20 percent below 1973 and 2 percent below 1972 but still the third largest soybean crop on record.

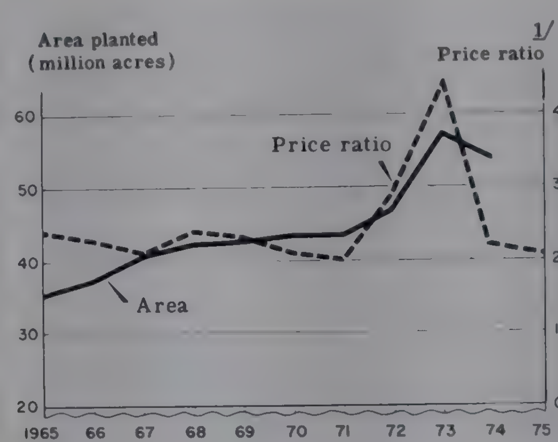
The area of soybeans for harvest, calculated at 21 246 000 hectares, represents the first substantial decline since 1959 and is about 1 619 000 hectares below the area planted in 1973. Yield is estimated at 1.58 tons/ha, nearly 0.27 ton below the record levels of the last two years and the lowest since the 1967 crop. The reduction in area had been anticipated because of the unfavourable soybean-maize prices at planting time and the wet spring.

Soybean demand in the current season is expected to continue strong. Smaller supplies will mean higher prices. Total soybean use could fall to about 37 million tons, some 7 percent below 1973/74. At this level, usage would exceed the prospected 1974 production. As a result, carryover stocks next September would be down to about a two-week supply.

Exports will be down, possibly substantially, from the record 14 751 000 tons exported in 1973. Tighter supplies and higher prices will tend to limit movement, but foreign supplies of protein meals are expected to be greater, thus reducing the need for United States soybeans. Sources of increasing protein supplies include Brazilian soybeans, Nigerian and Senegalese groundnuts and Peruvian fish meal. However, oilseed crops in India, eastern Europe and Canada will be smaller.

Major factors influencing United States domestic demand for soybean meal in 1975 will be the short feedgrain supply, down more than 20 percent, and downward adjustments in livestock feeding.

United States: Soybean area planted, and soybean-maize price ratio.



SOURCE: U.S. Department of Agriculture, Economic Research Service, NEG. ERS 405-74 (8).
[1] Soybean-maize price ratio based on average prices received by farmers in March. The 1975 ratio reflects March 1975 futures as of mid-August. 1974 and 1975 projected.

Conditions similar to those in the United States will tend to limit the use of soybean meal and other high protein feeds in other major areas of the world. Unfavourable livestock-feed price ratios, larger supplies of Peruvian fish meal, greater Brazilian soybean exports and economic slowdowns in some countries are the chief factors working against soybean meal expansion.

Demand will keep prices high

The tighter soybean supply situation and the continued demand will keep prices high. Prices received by farmers in autumn were averaging $7.65 per bushel (27.2 kg), sharply above the $5.50 received during harvest a year previously. Prices will probably continue to be high during the marketing year as soybean supplies tighten. Furthermore, United States farmers are strong holders of soybeans, and know that in the past two years it has been profitable to store soybeans at harvest and sell later.

Looking ahead to the spring of 1975, it may be difficult to expand United States soybean area from the reduced 1974 level. Farmers are free to produce their choice of crops for the market. Soybeans compete for land area on an economic basis with feedgrains, cotton and other crops. The prospective soybean-maize price ratio of close to 2 to 1 will encourage maize plantings (see graph). A price ratio of about 3 to 1 is favourable for soybean production.

The 1974/75 outlook for United States soybeans and soybean meal is thus for reduced supplies, strong demand, minimal carryover stocks next September and high prices. Expectations are for major adjustments in many sectors of the economy as consumers in the United States and other countries adjust to inflationary prices and slower growing or recessionary economies, and livestock producers adjust their operations to lessen the imbalance in livestock-feed price relationships.

Normally soybean meal and feedgrains complement each other in mixed feed rations. However, with tight supplies and higher prices of feedgrains, soybean meal may tend to become a partial substitute. This may be dampened by expected cutbacks in pig, poultry and dairy cattle numbers in the United States due to unfavourable livestock-feed and poultry-feed price relationships. Also, more beef cattle will be slaughtered directly off pasture rather than finished in feedlots.

Soybean meal prices are competitive with feedgrains and other substitutes such as urea. Current record feedgrain prices may encourage meal use. Also, if meal quality is lower because of weather-damaged soybean crops, more may be needed to maintain the nutritional value of the feed ration.

GEORGE W. KROMER, agricultural economist at the Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Editor's note: United States soybean production, equivalent to about 28 million metric tons a year in terms of soybean meal, represents more than half the world output of major protein meals used for animal production, and United States exports of soybeans and soybean meal account for over half the world trade in protein feeds (soybean meal equivalent).
The current status of the short 1974 soybean crop and the prospects for 1975 plantings in the United States are important to livestock and poultry producers in many countries.
Additional information on the world protein situation was to be included in the 1975 National Outlook Conference, held 9-12 December 1974 in Washington, D.C.

Congress Agrichem

The third congress on chemistry in agriculture will be held on the occasion of the international chemical fair, INCHEBA'75, from 24 to 27 June 1975 at Bratislava, Czechoslovakia. The role of vitamins, amino acids, nitrogenous, mineral and complementary substances in animal nutrition is included in the provisional programme as one of the four major areas to be covered by the congress.

Further information may be obtained from the organizational secretariat of the congress:

Dom techniky SVTS (House of Technology),
Ing. Jarmila Betinová,
Marxova ul. 16,
043 23 Kosice - Czechoslovakia

The husbandry and health of the domestic buffalo

W. Ross Cockrill (editor). Rome, FAO, 1974. *xiv* + 993 pages, numerous tables and illustrations. Price: US$20.00 or £8.00. (In English)

The domestic water buffaloes number about 150 million. They are a major source of farm power and in many areas they are important producers of milk. Buffaloes are also a good source of meat, although their potential in this regard has by no means been fully exploited.

Many workers have studied the water buffalo, and some research has been carried out. However, both these studies and the buffalo itself have been largely ignored by the scientific community and by agriculturists generally. FAO has taken an important step to correct this situation by bringing together in an impressive volume the considerable amount of information that is available.

The body of the book is organized into two parts. Part I contains specialized chapters dealing in turn with (*i*) species, types and breeds, (*ii*) colour and pattern, (*iii*) genetics, (*iv*) blood groups and protein polymorphisms, (*v*) environmental physiology, (*vi* and *vii*) reproduction, (*viii*) nutrition, (*ix*) diseases, (*x*) parasites and parasitic diseases, (*xi*) management, conservation and use, (*xii*) the working buffalo, (*xiii*) milk production, and (*xiv*) meat production. This section, which was prepared by nine authorities, fills 400 pages and is supplemented by 124 illustrations.

Part II, which deals with the world distribution and potential of the water buffalo, contains chapters dealing in turn with the buffaloes of (*i*) Oceania, (*ii*) Asia, (*iii*) the Far East, (*iv*) the Near East, (*v*) Africa, (*vi*) Latin America, and (*vii*) Europe. This part is also supplemented by excellent illustrations, 97 in all.

In addition to these two major parts, the book contains a foreword by Sir John Grenfell Crawford, and an epilogue describing the background of the undertaking and acknowledging the contributions of 172 individuals and institutions who cooperated in the compilation of the great mass of information contained in this volume. Also, there is a full bibliography occupying 169 pages, and a comprehensive subject matter index. It is also worthy of note that a number of the illustrations in Parts I and II are in colour.

It is quite rightly pointed out in the foreword that this publication brings together much of the available knowledge on the water buffalo, and provides a comprehensive review of the status of the buffalo in all the countries where it is of any importance in the agricultural scene (except China, on which a separate monograph is being prepared). Thus, *The husbandry and health of the domestic buffalo* provides a focal point for future buffalo studies and should also stimulate research which will find practical application in all these countries.

This publication is essential for anyone who has a serious interest in the water buffalo, whether he be research worker, teacher, student, extension worker or practical farmer interested in the improvement and efficient use of the buffalo. For the animal scientist it is a must, whether his specialization be genetics, physiology of reproduction, nutrition, feeding and management, disease and parasite control, or the special problems of milk, meat or work production.

R.W.P.

The Charolais breed

La race charolaise. Institut national de la recherche agronomique (Département de génétique animale), 78350 Jouy-en-Josas, France. 1973. 2 vols. Vol. I, xii + 233 pages; Vol. II, vii + 339 pages. Price: FF70. (In French)

This publication in two large volumes is a joint effort of researchers and teachers of the Département de génétique animale of the Institut national de la recherche agronomique (France). It covers all features of the Charolais breed. Most of the findings from outside France are compiled in Volume I, while Volume II deals with the background and history of the breed, its distribution in France and the results obtained in that country. It reviews, objectively, the adaptability of the breed to the tropics and subtropics, breed characteristics such as fecundity, fertility, calving difficulty, milk production, mortality and beef traits (performance records relating to growth, rate of gain, efficiency of feed utilization, conformation, carcass quality, etc.). A bibliography is provided at the end of each chapter.

It is regrettable that the presentation of this enormous mass of data is not more concise; nevertheless, the invaluable information it contains and the worldwide interest in the Charolais breed would justify an offset run of more than 500 copies.

P.A.

Cheeses made from goat milk

La fabrication du fromage de chèvre fermier. J.C. Le Jaouen. Paris, Société de presse et d'édition ovine et caprine, 1974. 213 pages, numerous illustrations. Price: FF30. (In French)

Cheese-makers and technical staff, managers and students, as well as teachers who wish to know more about the technology of goat cheeses which they manufacture, have heard about or simply enjoy as gourmets, will read this 213-page book to great profit. It is attractively presented and well laid out. For those who know its author and are aware of his professional competence, it will come as no surprise; for others, it will provide a pleasing contact with a field of dairy technology for which precise data and observations remain scarce.

Professionals will obtain interesting and valuable information on the properties of milk, and of goat milk in particular. In the chapter devoted to the basic principles of cheese-making and in the one entitled "Conduite pratique de la fabrication fermière d'un fromage de chèvre," they will find answers to many questions, as well as details of processing, step by step, from milking to the curing of cheese. Defects of various origins and nature are described in a concise and accurate manner.

Processing equipment and the basic requirements to be observed in the installation of cheese-making equipment are also dealt with.

The characteristics of 71 different French cheeses made from goat milk are reviewed in a single 24-page chapter, a valuable digest that permits the reader to differentiate between the many varieties of goat cheese.

"Dura Lex, Sed Lex" is a short chapter for those who are interested in cheese regulations; it will give them the opportunity of acquainting themselves with current legislation.

This publication is in every respect a valuable source of information and a handy reference book.

J.R.

Crossbreeding beef cattle, Series 2

M. Koger, T.J. Cunha and A.C. Warnick (editors). Gainesville, Fla., University of Florida Press, 1973. 459 pages. (In English)

Although crossbreeding has long been the standard system for beef production in the United Kingdom, it is in the United States that the method has been most thoroughly explored experimentally, and it is now being commercially exploited most effectively in the southern states. It is this interest which led the organizers of the Annual Beef Cattle Short Course at the University of Florida to devote the twentieth course (5-8 May 1971) to the theme of crossbreeding.

The 44 chapters in this volume comprise the papers presented by the 36 contributors to the course. The size of the book indicates the increase in attention to this subject since the publication in 1963 of the record of the previous course on crossbreeding, which was held in 1961 and ran to only 228 pages (see ABA 31: No. 2614). Over half the chapters (26) concern crossbreeding of zebu × European cattle in the southern United States. In addition, there is a chapter on general principles (Stonaker) and several on crossbreeding in other areas, including the northern United States and Canada (Warwick, Willham, Wiltbank), Europe (Maule), Australia and New Zealand (Lamond), Latin America (Joandet, Plasse, Salazar) and South Africa (Bonsma). All aspects of the subject are covered, including systems of crossbreeding and effects on reproduction, growth, feedlot performance and carcass characters. Some articles are reviews and some describe original experimental work, either published or unpublished.

This is a very important book and its message is clear — crossbreeding is a good thing. However, it is difficult to summarize the results more scientifically and to add the necessary provisos and qualifications. Fortunately, one of the editors has summarized the main results in a concluding chapter. Some of his conclusions are as follows:

1. In terms of weight of weaned calf per cow mated the progeny of crossbred cows exceed the average of purebred controls by 27-46 percent in the case of zebu × European crosses and by 12-17 percent for crosses between European breeds.
2. The amount of hybrid vigour for liveweight increases from birth up to weaning and then declines. For feedlot gain and carcass grade it is negligible.
3. The major portion of the total advantage from crossbreeding comes from the use of crossbred dams. Progeny from F_1 dams mated to a third breed were only slightly superior to backcross progeny, and progeny from a criss-cross or rotational crossing system were only slightly inferior. As expected on theoretical grounds *inter se* mating of F_1 bulls and cows leads to a considerable decrease in hybrid vigour.

In a final chapter the criss-cross breeding system is advocated — especially for zebu × European breeding in environments comparable with the Gulf Coast. It is simple in having only two breeding groups; all the females are crossbreds; there is scope for selections among females, and heterosis is almost as high as for breeding from F_1 females. The reviewer is in entire agreement with this line of argument.

I.L.M.

Q Fever and its geographical distribution

Das Q-Fieber und seine geographische Verbreitung. N. Thiel. Duncker & Humblot, Berlin-München, 1974. 165 pages. Price: DM38. (In German)

Q Fever is a rickettsial disease of man and of various species of warm-blooded animals. It is transmitted by ticks from wildlife to domesticated species of livestock, and man; cattle, sheep and goats are the main sources of infection to man. Natural foci, with endemic occurrence of the infection, were identified in the Mediterranean and Black Sea areas and in regions with dry and warm climates in central Asia, Africa, North America and Australia. The nomadic movement of cattle herds and of sheep and goat flocks contributes to the distribution of the infection on a large scale.

An introductory chapter describes the causative agent, the symptoms of the disease in man and livestock, and the diagnosis, therapy, epidemiology and control of the disease.

The second part deals with a detailed description of the incidence of the disease in various parts of the world and is followed by a discussion of occurrence in relation to climatic and geological factors and prevailing animal husbandry practices.

Two maps and a comprehensive bibliography contribute to the usefulness of this monograph.

T.S.

Handbook on cheese - cheeses of the world from A to Z

Handbuch der Käse — Käse der Welt von A-Z. Heinrich Mair-Waldburg. Volkswirtschaftlicher Verlag, Kempten, Federal Republic of Germany. 902 pages. (In German)

This encyclopaedic book consists of three parts: A, B and annex. Part A deals with the history of cheese-making and cheese in literature; cheese as food; production, trade and consumption of cheese; alpine cheese-making; definition, legislation, FAO/WHO Code of Principles concerning milk and milk products, FAO/WHO international individual cheese standards; technology (including food additives); and packaging.

Part B gives a complete list of world cheeses, with summarized information on the places of manufacture; shapes, weights, dimensions; type of milk used for manufacture; main manufacturing criteria; and composition, etc.

The annex contains tables of cheese groups (according to consistency) giving designations of shape, dimension, weight and compositional data of cheeses produced in a similar manner in many countries.

The book is very well written and illustrated, and contains a wealth of historical, technical, technological, legal and economic information, making it extremely useful for everybody interested in these fields or in food science in general.

F.W.

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